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The Polar Axis Adjustment of Photographic Telescopes

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A number of years ago E. S. King[1] described a photographic method for adjusting the polar axis of a photographic telescope. Previously King[2] had demonstrated that the guiding of such a telescope is simplified when the polar axis is directed accurately towards the *refracted* celestial pole. Much experience with the Harvard sky patrol cameras has demonstrated that surprisingly good stellar images can be obtained by an accurately driven camera without guiding when the axis adjustment is precise within a few seconds of arc. A simple extension of King's method, involving in addition a measuring engine or plate-measuring device, transforms the method from a qualitative method to a quantitative method of great accuracy and speed.

The preliminary adjustment of a photographic telescope provided with a guiding telescope can be made by the classical visual method. The north or south apparent drift of a star near the meridian and equator indicates an east-west error in the polar adjustment while a similar drift near the East or West points indicates a north-south error. The method is crude in the latter case because of differential refraction.

In the photographic method King's rules for making the polar exposure and for determining the direction of the corrections are used. The polar adjustment setting screws must be tightened to an appropriate high tension, the camera focused, and the drive set for the proper rate before the accurate polar-adjustment exposure is begun. The length of the polar exposure should be determined in advance. If the adjustment is already fairly good, a 3-hour exposure will usually be appropriate. Otherwise a shorter exposure and a preliminary adjustment should be made.

The exposure with drive is started at an east hour angle equal to one-half the desired exposure time, say $1^h\,30^m$ E for a 3-hour exposure, and the camera is directed towards the refracted pole. The camera aperture should be adjusted to permit only moderate emulsion fogging during the exposure. The drive is stopped at a west hour angle equal to the east starting hour angle; the telescope is then allowed to trail for 5 or 10 minutes so that the direction of the trails induced by the inaccurate polar adjustment can be determined. These latter trails are

[1] "A Manual of Celestial Photography," p. 31, Eastern Science Supply Co., 1931.

parallel arcs of a circle equal in length for a considerable distance from the pole, in contrast to the polar concentric trails induced by the rotation of the Earth while the drive is stopped.

The direction of the correction in King's method is now determined (for a direct lens camera) by holding the developed photographic plate or film between the eye and the pole, parallel to its mean orientation in the camera and then turning it clockwise through 90° in its own plane. Hence one views a plate through the glass. The apparent direction of the progressive motion of the star images during the polar adjustment exposure now measures the direction of the necessary correction to the north end of the polar axis.

In the Southern Hemisphere the plate is rotated 90° *counter*-clockwise and the corrections apply to the *south* end of the polar axis.

The polar adjustment correction can now be made precisely instead of qualitatively if the polar-adjustment trails are measured and if certain data of the camera and mounting are known. Suppose that the mean meridian line on the photographic plate is known. For most cameras the meridian line is sufficiently parallel to an edge of the plate for purposes of measurement. If not, the mean meridian line can be determined after the exposure by setting the camera at zero hour angle and trailing the camera in declination.

Measures are now made of the chord of the polar-adjustment arcs on the plate, the component parallel, l_{ns}, and perpendicular, l_{ew}, to the meridian at the middle of the exposure. Some care should be made in these measurements to allow for the width of the stellar images.

Let d be the distance on the photograph of the refracted pole from the instrumental pole in the same units as l_{ns} and l_{ew}, and let t be the length in arc of the polar adjustment exposure. A study of the simple geometry will show that

$$d = (l^2_{ns} + l^2_{ew})^{\frac{1}{2}}/2 \sin (t/2). \tag{1}$$

Now the polar axis adjustment for a photographic telescope is usually made by turning screws or bolts against effective lever arms that adjust the polar axis in the horizontal and vertical directions independently. Suppose that these adjustments take place in and perpendicular to the horizontal plane. Let L_{ew} and L_{ns} represent the lengths of these respective lever arms, P_{ew} and P_{ns} the pitch or distance between the respective screw threads and F the focal length of the telescope, all measured in the units of the measuring engine.

Then the number of revolutions, R_{ew}, through which the east-west polar adjustment screw must be turned to correct the axis by the proper component of d is easily found to be

$$R_{ew} = L_{ew}\, l_{ns}/2\, P_{ew}\, F \sin (t/2) \cos \phi \tag{2}$$

where ϕ is the astronomical latitude.

In case the east-west polar adjustment is not made in the horizon plane but in a plane including the pole, the latitude term is omitted from Equation (2).

Correspondingly the number of revolutions, R_{ns}, through which the vertical polar adjusting screw must be turned is given by

$$R_{ns} = L_{ns}\, l_{ew}/2\, P_{ns}\, F \sin (t/2). \qquad (3)$$

The sense of the corrections given by Equations (2) and (3) can most easily be determined by King's rule, as given above, and by inspection of the polar adjustment equipment for a given telescope. The opposing screw should be released the prescribed number of revolutions before the advancing screw is tightened. An accuracy of at least 1/100 Rev. can be obtained by the use of a long wrench and a rule to determine the motion of the end of the wrench.

For a reflecting telescope Equations (2) and (3) are unchanged but the sense of the corrections is confusing to determine. One holds the emulsion side of the plate towards the eye for an odd number of reflections in the optical system, and the glass side towards the eye for an even number. The writer has found that at least one of the corrections usually is made in the wrong sense on first try.

In the Southern Hemisphere Equations (2) and (3) remain valid but the sense of the corrections is changed according to the modification of King's rule as given above.

The writer has found that this quantitative method of adjusting polar axes is rapid and precise on small telescopes, and on larger telescopes of rigid construction. Many larger telescopes are subject to so much flexure that the polar adjustment cannot be precise. In such cases accurate guiding near the pole requires a moving plate-holder or a slow motion adjustment about an axis perpendicular to the declination axis.

The quantitative polar adjustment can be facilitated by tabulating in advance the coefficients of l_{ns} and l_{ew} in Equations (2) and (3) for a few chosen exposure times such as 30^m and 3^h (or 4^h as a very simple case). One careful adjustment from a 3-hour polar exposure is usually sufficient for a good polar adjustment, although a check exposure should be made after each adjustment to insure that no errors were made in the settings and to guard against an irregular response of the instrument to the motion of the adjustment screws.

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Comets and Shower Meteors

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SUMMARY. Comets are slowly revolving aggregations of small particles that have sublimed like snow in those cold regions of interstellar space where there happens to be little motion or turbulence. Their resulting small "velocity at infinity" causes all except a small number of comets to have velocities whose divergence from parabolic velocity is too small to be measured. The porosity of the particles resulting

from sublimation at low temperatures and concentrations makes possible the production of many tails.

Since shower meteors appear to be usually, if not always, debris of disintegrated comets, the discussion of comets includes shower meteors and any sporadic meteors that may also be cometary debris. Conversely, the properties of shower meteors are assumed to apply to cometary particles.

Meteorites are excluded from this discussion.

A. Members of Solar System. There is a general agreement that comets are members of the Solar System, but there is a disagreement as to the manner in which they became members. The following suggestions have been offered:

1. Comets are debris from the formation of the planets.

2. Comets, according to Bobrovnikoff's[1] hypothesis, were captured when the Sun blundered through a dark nebula.

3. Comets are wanderers from interstellar space.

4. Comets have been formed within the Solar System.

1 & 2. *Planetary debris or captured from nebula.* Such serious objections to both of these suggestions have been stated by Russell[2] that their tenability seems dubious.

3. *Wanderers from space.* The lack of hyperbolic orbits indicates, according to Russell, Dugan and Stewart,[3] that comets are not wanderers from interstellar space.

4. *Formed within Solar System.* By eliminating other possibilities, Russell, Dugan and Stewart conclude that "the comets so far observed have always been associated with our system and are not visitors from the depths of space."

B. Properties of Comets. Any discussion of the origin of comets must be based on their pertinent properties and on the properties of their debris, the shower meteors. These pertinent properties are:

1. Comets are swarms of widely separated particles.

2. The particles in particular meteor showers, and hence in particular comets, are fairly uniform in mass. For example, the largest particle in the Giacobinid meteors, according to Watson,[4] has about 1,000 times the mass of the smallest, a range in diameter of 10.

3. All the particles of shower meteors are exceedingly small. Watson[5] has tabulated the estimated masses of meteors diminishing in brightness to magnitude 10. From his table it appears that only one meteor in 50,000 has a mass exceeding one gram.

4. The spectra of shower meteors show, according to Watson,[6] that they are composed of elements common in stone meteorites. Whence comets are composed of the same elements.

5. Shower meteors, and therefore cometary particles, are obviously

solid. Such small aggregations, if gaseous, would be thermally dissipated long before they reached the Earth's orbit, while aluminum, calcium, silicon, iron, etc., or their salts would not be molten until well within the orbit of Mercury.

6. Cometary particles are apparently porous, for otherwise adsorption of tail gases would seem to be impossible.

7. Tails of comets are formed of simple and fragmetary molecules of which the following, according to Russell, Dugan and Stewart[7] have been identified:

$$C_2,\ CN,\ CH,\ CH_2,\ NH,\ NH_2,\ OH,\ CO+,\ N_2+,\ OH+.$$

8. Long-period comets, from which short-period comets obviously have been derived, move in random orbits whose divergence from parabolas is too small to be measured.

C. Origin of Comets. Since comets are composed of solid particles there seem to be two possibilities:

1. Cometary particles are fragments of larger bodies.
2. Cometary particles have condensed from gases.

1. *Fragmentation.* Collision and tidal break-up are the only known processes for shattering celestial bodies. Collision between solid stone bodies, even if their material contained gas under pressure, could hardly smash them so thoroughly that the average mass of a particle would be a small fraction of a milligram and that practically none would have a mass of a gram. Tidal disintegration, even if the body were entirely liquid, would not be competent to effect such minute and complete fragmentation. Even if the fineness of cometary particles could result from fragmentation, the random orbits could not result from any localized disintegration.

2. *Condensation.* Meteor showers, which have been frequently called "celestial blizzards," suggest that comets have been formed by sublimation like snow of terrestrial blizzards. Provided sublimation can occur, it becomes an attractive hypothesis of the origin of comets, for all the properties of comets, both mechanical and chemical, seem to be the normal result of such an origin. The existence of nebulae throughout the Galaxy indicates that not only is such sublimation possible but that it is a fairly common phenomenon.

Snow sublimes in our atmosphere whenever:

a. The temperature of the air is below the freezing point.

b. The concentration of moisture is greater than the aqueous tension.

c. There are dust particles or other nuclei on which snow can condense.

The discussion of the details of sublimation of particles that form

comets or nebulae is necessarily difficult because of the paucity of data on the chemical, physical, and mechanical properties of stray matter in space. However, according to Whipple,[8] "Dutch astronomers have recently shown that these gas atoms (Whipple is referring to stray atoms in space) slowly coalesce into chemical combinations and dust particles."

The temperature of particles and bodies in interstellar space is so low that, with the exception of helium and perhaps some other "permanent" gases, the concentrations of such elements and molecules as exist in space exceed their vapor tensions.* Moreover, electrons and charged particles, which Wilson's cloud chamber shows are adequate nuclei for condensation, exist in space. Whence it would seem that sublimation in space would occur, although the process would necessarily be very indolent because of the very small concentration of stray matter. However, in 3,000 million years enough particles might sublime to form comets and nebulae.

The attraction of vagrant stars has imparted irregular motion to the stray matter in space causing currents and local concentrations, but in general the motion and currents have been very slow, for the stars are spread so far apart that most of the stray matter has never been near any star. The rate of sublimation would be more rapid in concentrations of stray matter, and in these concentrations aggregations would form, which, like Whipple's "proto-planets," might be called "proto-comets."

Very slowly each chance-formed proto-comet would grow at the expense of other proto-comets, would gather to itself other chance particles until, when large enough, it would become a comet. From the slight random motion of its particles the proto-comet would acquire sufficient rotation to neutralize its slight gravitational cohesion.

The particles of a particular comet, like the snowflakes in a particular storm, tend to be of uniform size because each comet has condensed from a limited region in which there probably would not be a great variation in the temperature, concentration, or composition of the stray matter.

D. Orbits. Particles condensed from stray interstellar matter, even in chance concentrations, must be both small and far apart, and the velocity of escape from any concentration correspondingly small. Relative motion greater than the escape velocity would prevent the formation of comets, and hence usually, but not necessarily, comets could form only in quiescent regions of space. Consequently their motion in space would nearly always be slow, that is their "velocity at infinity" would be small. Therefore, the velocity of comets approaching the

*Note: Parson[9] estimates that the vapor tension of iron at 273° K. is of the order of 10^{-44} gm/cm^3, and that of calcium oxide at 273° K. is uncertainly of the order of 10^{-102} gm/cm^3. In discussing the condensation of stray matter on planetary bodies, Jeffreys[10] used 10^{-29} gm/cm^3 as the concentration of stray matter in space.

Sun or any other star would seldom be measurably divergent from the parabolic velocity. Those comets whose velocities were less than the parabolic velocity would revolve around the Sun or another star in elliptical orbits whose orientations and eccentricities would be truly random. Those comets whose velocities exceed the parabolic velocity revolve around the Sun or another star in likewise random hyperbolic orbits. In the very few cases where a comet formed near the Sun or another star, the orbits might be measurably divergent from a parabola.

From time to time, stellar perturbations cause some of the orbits in the outer reaches of the Solar System to become sufficiently eccentric for the comets to come close enough to the Sun for the perturbations of the planets to take over. Most of these comets are hurled from the Solar System on hyperbolic orbits, but a few remain to become long-period comets. Of these long-period comets a few are transformed by planetary perturbations into short-period comets, but the great majority are lost.* Those comets not lost to space, if they come within the orbit of Mars, lose their supply of tail material after repeated growth of tails and also are usually destroyed by solar or (rarely) planetary tidal forces. Their debris, the shower meteors, are picked up by planets in a relatively short time, by astronomical scale. Whence it is evident that there is a constant renewal of the supply of comets from the outer reaches of the Solar System.

E. Properties of Cometary Particles. In the cold rarefied environment of outer space, chemical action is probably almost nil. Therefore there can be little or no formation of compounds except that ionized atoms may occasionally unite to form diatomic and very rarely polyatomic molecules, thus producing particles which are probably porous uncompacted masses of fragmentary molecules, principally monatomic. This structure would result in a matrix of non-volatile materials such as Fe, Al, Ca, Mg, Si, etc., to whose surfaces the volatile materials would be adsorbed. The structure of the particles might be compared to charcoal used in gas masks, except that the particles are far more porous. The ability of charcoal to adsorb and retain gases is proportional to its porosity because the amount of gas adsorbed is proportional to the amount of surface on which it can condense.

In our atmosphere snow is sublimed at about 270° K. and in an environment that contains about 10^{25} times as much matter as exists in space. Uncertainly arguing from analogy, it seems probable that the cometary particles are much less compact than any snowflake, *i.e.*, they are fluffy particles honeycombed with interstices. The ability of comets to grow many tails seems to demand a very porous structure of cometary particles, for unless the adsorbed tail material were shielded, they would all disappear during their first exposure to solar radiation. Every

*Note: H. A. Newton[11] estimates that for every comet in the Jovian family of comets, there has been a wastage of the order of a quarter of a million comets.

comet that approaches close enough to the Sun to grow a tail is exposed for several years to solar radiation of sufficient intensity to dissipate a large quantity of tail gases in the vacuum conditions of interplanetary space. Even water, which is less volatile than any of the observed tail gases, and probably less volatile than any material in the particles from which tail gases are derived, would begin to volatilize long before the comet reached the orbit of Saturn. If black body absorption of solar radiation is assumed, the quantity of ice* that would evaporate at the distances of the various planets, provided all the energy is utilized, is:

Saturn	10 gr/cm²	per year
Jupiter	60 gr/cm²	per year
Mars	400 gr/cm²	per year
Earth	1,000 gr/cm²	per year
Venus	2,000 gr/cm²	per year
Mercury	7,000 gr/cm²	per year

Obviously there must be some mechanism to retard the evaporation of tail gases during the long years of exposure to solar heat, for otherwise the growth of many, or even of two tails would seem to be impossible. The mechanism suggested is inherent in the porous structure of the particles, for in such particles the gases are not only shielded from the Sun by being hidden in the pores and interstices of the non-volatile matrix, but they are held by adsorption. A considerably higher temperature is required to release adsorbed gases than to evaporate the same gases. This requirement of higher temperatures would seem to be consistent with the fact that tails are not produced until a comet is about at the distance of Mars.

F. Composition of Tails. Even the simple molecules forming the tails of comets are probably more complex than before they were expelled from the comet. When comets approach the Sun, some of the adsorbed gases in the cometary particles are released by solar heat. At the instant of release, both the concentration and the chemical activity are almost infinitely greater than in outer space, and the gases, assisted by the actinic solar rays, combine to form the simple molecules observed in the tails of comets.

Grateful acknowledgment is made to Dr. Otto Sieplein for his assistance.

References

In addition to references specifically cited, the author is indebted to Fletcher G. Watson's "Between the Planets" for many of the data on which this hypothesis of the origin of comets is founded.

[1] N. T. Bobrovnikoff, *Lick Observatory Bul.*, No. 408, 1/17/29.
[2] H. N. Russell, "Solar System and its Origin," 1935, p. 8-9 and 33-43.
[3] Russell, Dugan and Stewart, "Astronomy," Vol. I, Rev. Ed., 1945, p. 426.
[4] F. G. Watson, "Between the Planets," 1941, p. 137.
[5] *Ibid.*, p. 115.

*Note: The energy required to vaporize water is from 2 to 50 times as great as the energy required to volatilize other terrestrial gases. Therefore the quantity of other gases evaporated from the frozen state would be from 2 to 50 times as great as the quantity of ice.

[6] *Ibid.*, p. 107.
[7] Russell, Dugan and Stewart, "Astronomy," Vol. I, Rev. Ed., 1945, p. 436.
[8] Whipple, F. L., *Sc. Amer.*, May, 1948, p. 36.
[9] A. L. Parson, *Nature*, Vol. 153, p. 707.
[10] H. Jeffreys, *Nature*, Vol. 153, p. 140.
[11] H. A. Newton, Quoted by Watson in "Between the Planets," 1941, p. 85.

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Equatorial Acceleration of Sunspots

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INTRODUCTION

At least as far as the astronomer is concerned, the sun serves several other purposes besides that of sustaining life. The sun is, as everyone knows, the closest star to the earth. In fact it is the only star whose surface may be directly observed. By studying its surface the astronomer hopes to be able to draw conclusions as to the nature of other stars. The sun presents an ever-changing panorama, and keeping up with the sun requires an ever constant vigil. But constant observations of the sun have paid off. A good example of this was the discovery of helium on the sun. In the process of these observations many interesting phenomena have been recorded. Some of them have now been explained. Others, however, still remain a mystery.

The object of this paper is to discuss one of these phenomena, namely, the equatorial acceleration of sunspots. The paper will be divided into three parts, the first part will give a general description of this acceleration, the second part will cover various theories attempting to explain this phenomenon, and the third part will give some of the author's own viewpoints on the subject.

I

One of the most baffling of all the phenomena connected with the sun is change of the rotational period of the sun's surface as the latitude changes. As far back as 1853 Carrington had established the fact that the sun was not rotating as a solid body. Actually the sun was rotating such that spots near the equator completed one revolution in a shorter period of time than those spots at a higher latitude. This "equatorial acceleration" is of such magnitude that the equatorial period is some two days shorter than that at a latitude of 40 degrees.

The table at the end of the paper gives the results obtained by various observers for the daily rotation of the sun at different latitudes. Although there are minor discrepancies among the observers, and also between spot observations and spectrum investigations, the significant point to note is that all show an increase of rotational speed with a decrease of latitude, an equatorial acceleration.

Different observers have at various times attempted to state in a mathematical equation how this acceleration varies. In no instance were

these equations derived from purely theoretical considerations. Rather they were empirically derived, made to fit the observations as it were.

Carrington, using observations of 954 different sunspot groups obtained the expression:

$$X = 865' - 165' \sin^{7.4} l.$$

Here X is the daily motion in minutes of solar longitude, l is the latitude in question. Perhaps the oddest thing to note about this equation is the exponent of the sine term. However, it should be emphasized that Carrington arrived at this equation from a purely empirical standpoint, and there is no theoretical reason for such an odd exponent.

Faye assumed that the exponent should be two, and using the same data arrived at the equation:

$$X = 862' - 186' \sin^2 l.$$

This equation agrees in most instances as well as does Carrington's formula.

Spoerer, using his own observations as well as those of other observers, such as Secchi, obtained the formula:

$$X = 1011' - 203' \sin (41° 13' - l).$$

Still another expression was obtained by Tisserand from observations of 325 spots in 1874-75. It is as follows:

$$X = 857'.6 - 157'.3 \sin^2 l.$$

This formula is not based on as many observations as the formulas of Faye and Carrington, and should not be considered to be quite as accurate.

The wide variation between the different formulas should be noted. All of them give acceptable results as far as the observations are concerned, and yet not one gives much of a clue as to what forces are acting.

The first investigations of the equatorial acceleration utilized sunspot data. Later workers made use of other means of attacking the problem. It is a well known fact that if an incandescent body is approaching or receding from the observer the wave-length of the emited light will seemingly be shortened or lengthened, respectively. This effect is commonly known as the Doppler effect. Here then was a means of determining the rotational period of the sun. Because of the Doppler effect, the spectrum of the eastern edge of the sun, which is approaching the observer, will be displaced toward the violet end of the spectrum with respect to the spectrum of the center of the sun, where all the motion is perpendicular to the line of sight. Similarly the spectrum of the western edge of the sun will be displaced toward the red end of the spectrum. Furthermore, the amount of displacement is proportional to the velocity of approach or recession. The table at the end of the paper shows the results of observers using this method. It will

be noted that the data from this method cover a wider range of latitudes than the sunspot data. This is because of the fact that sunspots are seldom seen at a latitude higher than 40 degrees. The spectrum of any part of the sun may of course be obtained. The results obtained from the spectrum are in reasonable agreement with the results of the sunspot observations.

A third method of investigating the rotation of the sun is through observations of the motion of the faculae. Faculae are clouds of hydrogen and calcium which are floating in the chromoshere of the sun's atmosphere. Results obtained by this method are somewhat more uncertain than those obtained by other methods. This is partly due to the fact that faculae are ill-defined in comparison to sunspots.

In general, however, all the methods give similar results.

II

One of the early theories which attempted to explain the equatorial acceleration was that proposed by Sir John Herschel. He suggested that meteors striking the sun's equator would cause the acceleration.

The first problem encountered in this theory is that the meteors would both have to revolve in the same direction as the sun's rotation around its axis and would have to be concentrated in a plane nearly coincident with the equator of the sun. The first condition could very well hold. The second is less likely to hold strictly enough. Certainly neither condition is out of the question. The real objection comes from the fact that, if meteors were the cause of the acceleration, the rotational period of the sun should be becoming shorter and shorter. But this is not the case evidently, for comparison of old data with more recent data shows no apparent change in the period of the sun. It might be argued that enough time has not elapsed since the first observations of the sun to determine a change in the acceleration. However, as C. A. Young says in his book, "The Sun," "It would seem probable that any 'driving,' sufficient to establish nearly two days difference between the rotation periods at the equator and at latitude 40 degrees, must have produced a very sensible effect within 300 years."

Other theories account for the equatorial acceleration by saying that it is caused by masses of condensed gases falling toward the sun. This theory in essence states that eruptions such as prominences, would cause gases to attain great heights. Suppose that they then remain at this height long enough to gain the velocity of rotation of the particular height at which they are "resting." This velocity must be greater than that at the level from which they came. Meanwhile the gases would be cooling and condensing, and finally would reach a state where they would fall toward the center of the sun. The author of the theory supposes that these falling masses would constitute the photosphere. These masses would be observable, and they would have a velocity greater than that to be expected at the observed level. Furthermore these observed velocities would decrease as the poles were approached,

which is an observable fact. This theory would call for the falling masses to be more easily visible than the stationary or rising gases. Young in his book, "The Sun," goes on to say that if only the sunspots are being considered, masses falling from 15 or 20 thousand miles would be sufficient to account for the acceleration.

Faye has proposed still another theory. He states that instead of the acceleration being due to matter falling toward the sun, it is due rather to gases rising from below the visible surface from a certain given distance. If this depth were to vary with the latitude it would be easy to account for the acceleration. Assuming this to be the case his formula which states that the retardation at high latitudes is proportional to the square of the sine is verifiable. However there is no way to account theoretically for a varying depth from which the gases would arise.

These then are some explanations that have been put forth. Even today the whole problem remains a mystery. Harlan True Stetson in his recent book (1947) summed up the matter in a very few words. He said, "So far we have no explanation for the speeding up of the sun's rotation as the sun's equator is approached."

III

The problem of the equatorial acceleration ties in with most of the other problems concerning the sun. In order to obtain any ideas at all as to the forces that are at work, those that might be the cause of the acceleration, one has to investigate everything from the sunspots themselves and the prominences to the internal temperatures, pressures, and densities of the sun. Some of the aspects of the sun may be observed directly, but others must be inferred from an extension of the observed by theoretical means. To do justice to the problem of equatorial acceleration would require years of work. However, solar observations are constantly being made, and the problem may be solved in the not to far distant future.

Part three of this paper will give some of the author's own viewpoints and also some of the recent advances toward the solution of the problem.

A. Herschel's Meteor Theory. Meteors have for a long time been the "Puck" of the solar system. Great meteor showers have led people to believe that the world was coming to an end, the craters of the moon have been blamed on meteors, and Herschel even advanced them as the reason for the equatorial acceleration. It is the author's own opinion that meteors should be absolved from all blame of causing the acceleration for the following reason. When meteors enter the earth's atmosphere they usually "burn out" in a matter of seconds due to the friction of the air. Moreover it has been found that this burning up takes place in the neighborhood of 60 miles above the earth's surface. At that height the density of the air must of course be low. Since the density is so low the passage of a meteor would have little effect in accelerating the air as a whole. This discussion may be extended to

the sun in a like fashion. On the sun we must add one more condition however, that of the high temperatures that prevail. It would seem therefore that the meteors would not be able to get very close to the sun before they were completely vaporized.

Disregarding these arguments one might argue that the meteors had caused the acceleration in the distant past (since the effects of meteors large enough to affect the sun would be visible elsewhere in the solar system, which is not the case). However, it is easy to show that if the accelerating force was removed at some time in the past the sun should be slowly decelerating. Observations have not borne out this conclusion.

We are then forced to turn to internal forces for an explanation of the phenomenon of the equatorial acceleration. Theories based on this line of reasoning have been presented elsewhere in the paper. All of these theories call for moving masses of gas, either up from the interior, or falling from the upper solar atmosphere. Observation seems to indicate that both are in reality occurring. The sunspots have been shown to be patches of gas in violent motion, with a transfer of gases continually going on from one layer to another. Furthermore when a sunspot reaches the edge of the sun prominences are usually seen directly above it. Here again is gas in violent motion, so much so that gases are sometimes thrown 2 or 3 hundred thousand miles above the visible surface of the sun. Both theories considering the internal forces seem to have their conditions fulfilled, then.

Sunspots appear to be nothing more than vortices. It is at this point that we run into the seemingly endless cycle. It is a well known fact

OBSERVED SYNODIC DAILY ANGULAR VELOCITIES, X, FROM SUNSPOTS, PROMINENCES, SPECTRUM LINES

(Taken from Bigelow, "Atmospheric Circulation and Radiation.")

Latitude	Carrington Spots	Spörer Spots	Faye Spots	Tisser-and Spots	Bigelow high level prom-inences	Dunér Spec-trum	Halm Spec-trum	Adams Spec-trum	Means
90°	...	...	...	...	788′	616′	732′	705′	710′
85°	...	...	...	...	790	625	733	706	714
80	...	...	...	...	793	634	734	706	717
75°	...	...	...	...	795	642	736	709	721
70	...	...	...	...	799	656	741	714	728
65°	...	...	...	...	804	674	745	721	736
60	...	...	...	...	809	690	756	732	747
55°	...	...	...	...	815	714	768	740	759
50	...	...	...	...	824	740	780	752	774
45	...	...	...	...	832	768	792	768	790
40°	789′	810′	785′	793′	837	796	800	780	799
35	803	814	801	806	840	819	810	798	811
30°	816	819	815	819	842	833	822	813	822
25°	828	825	829	830	845	848	838	830	834
20°	840	833	840	840	846	860	850	844	844
15°	849	842	850	847	852	870	858	855	853
10°	857	853	856	853	859	880	866	866	861
5°	863	864	861	857	866	885	872	874	868
0	865	877	862	858	869	888	876	882	872

that when one part of a liquid moves faster than another part vortices are formed. Everyone has seen evidence of this in the whirlpools in streams. The same thing might happen on the sun, resulting in the sunspots. Due to the existing conditions on the sun these vortices could be so violent and eruptive as to throw gases into the upper atmosphere, which would cool, and fall back into the sun. Thus more acceleration would take place and more vortices would occur, and so on. It has been suggested that the equatorial acceleration might be due to the slipping of gas at one density over that of another density. This might be the solution to the problem. However, it is not as simple as this. Stabilizing forces would have to be considered, and such problems as the periodicity of sunspots must also be regarded.

In summary, the problem of the equatorial acceleration has long been bothering the astronomer, and he has still not reached any conclusions as to what is the actual cause. The problems of the sun are still some of the most baffling which confront the astronomer.

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Planetary Nebulae and Novae

By CHARLES DILLON PERRINE

The object of this note is to call attention to essentially erroneous interpretations of certain facts of observation relating to these bodies and the consequent failure to see their true bearing on the places of these bodies in the evolution of the stellar system. They are two in number.

1. The masses and motions of the bodies concerned in the outbursts of the novae.

2. The high velocities of the planetary nebulae and late-type stars and its bearing on the status of both planetaries and novae.

1. The generally accepted cause of the novae outbursts is that first proposed by Seeliger to account specifically for the great outburst of Nova Persei in 1901. As stated by him and repeated by theorists and investigators since, it is that the star has *entered* a cloud of cosmical matter or is *passing through* such a cloud. This conveys the not unnatural idea and is generally so interpreted, that the cloud of cosmical matter is *at rest* and that the star is moving. In fact some go so far as

to say that the star has encountered the cosmical cloud at a high velocity and giving the *high velocity of the star* as being the real cause of the encounter.

This presupposes, and can only be interpreted as considering, the cloud to be *immovable,* and therefore of immense size and mass, thus ignoring the fact that gravitation must cause the cloud to move also toward the star very much faster *unless,* and here is the *if,* the cloud is of *overwhelming mass!* A condition which the extremely ephemeral nature of the outburst at once categorically contradicts and renders untenable.

If the cloud were massive the star would either be enmeshed for a very long period during which the maximum would continue, or it would be captured outright and become a permanent member of the cloud body or system, results which are definitely negated by the actual ephemeral course followed, the certainty of which is not open to doubt. The correctness of this criticism, which is, however, so obvious as not to need further proof, will appear also later in considering the space velocities of the late-type stars.

We must assume, therefore, that the impinging cloud was small and only *a fraction as massive as the star,* that the velocity of encounter was high but was *nearly all of the cloud.*

2. In the attempt to locate the planetary nebulae, and Wolf-Rayet stars, in the evolutionary sequence on the basis of their special type as true nebulae, their high space velocities have been an unsurmontable obstacle as the large irregular nebulae, which have been considered the evolutionary starting point of our stellar system, are *nearly at rest* in that system, the velocities increasing through the *"early"* types O, B, A to the *"late"* types M, N.

Campbell in this contingency, and advocating the accepted order, even goes so far as to suggest that the planetary nebulae are condensing into ordinary stars but that they *form a class by themselves!* He considers that the Wolf-Rayet spectra of the nuclei of the planetaries, and the Wolf-Rayet stars, and their normal high velocities for that type also require a different classification.

This point of view as to the planetaries and Wolf-Rayet stars is not the correct one as we now know. In a certain sense the planetaries form a class by themselves but not in the ordinary evolutionary sense of the main body of stars. The planetaries are merely ordinary, late-type stars which have had their normal course interrupted by an encounter with cosmical matter, their subsequent course being a return, rapid or slow, *to normal* but in *no sense* the ordinary evolutionary process, the encounter being in reality a nova but so violent as to produce apparent stabilization over relatively long intervals.

The stellar velocities increase from *early type* and reach a maximum in the *late* types, according to the present accepted analyses of the observed radial velocities. In the course of the present investigation doubt

has been thrown on this increase, rather on its amount than on the fact, because of the increasing number of high velocities in the later types. The fact of the presence of many high velocities in the late types and their absence in the early types is, however, sufficient evidence of some such effect and justifies the consideration in the following connection.

Such an increase with spectral type explains the high velocities as being merely the normal, high, velocities of late-type stars, and have no relation other than spectral to the great extended, irregular gaseous nebulae assumed to be the starting point of the evolutionary process.

The velocities of only 47 planetaries are known but these are doubtless representatives and are enough for comparison with the velocities of late-type stars, as follows:

47	Planetary Nebulae	45 km per second
382	K type stars	33.6 km per second
73	M type stars	34.3 km per second

The K-type stars are included merely to strengthen by their greater numbers the velocity of the M-type stars.

The only data which I have of the velocities of Wolf-Rayet stars are found in a statement by Campbell that the velocities of 3 are *several times* that of the helium stars. This however, takes them definitely out of the low-velocity extended nebulae class and puts them in with the planetary nebulae where other considerations also place them. Obviously Wolf-Rayet stars are merely the central stars of novae outbursts.

While the number is small the fact of there being no exception and agreeing so fully with other characteristics makes certain their community of origin.

This comparison shows the velocities of the planetaries to be *higher* on the average by 11 km than the normal M-type, a condition which is assumed to result from the collision. This increase of velocity is of great significance the key to which lies in the velocities and masses of the star and cloud and the way in which the encounter took place.

First, we have the known velocity of the star, but can only speculate as to its mass and the velocity and mass of the cloud. We can, however, make some reasonable assumptions as to these and perhaps by successive approximations reach some idea of what the masses and velocities of the impinging clouds have been. The most important is the fundamental question of the original velocity of the cloud. What has been the space velocity of the cloud before and at the time it came under the influence of the star? The most reasonable assumption is that it was essentially at rest or had a negligible velocity, which would balance out to zero for all. But it is necessary to consider also velocities *equal* and *higher* than that of the star, in order to discover and test the most probable hypothesis.

If our typical impinging cloud was at rest the velocity of the star would begin to increase as star and cloud approached each other under

the influence of gravitation, in inverse ratio of the masses. For example if the mass of the cloud were 1/100 that of the star the *star's* velocity would be 1/100 that of its "parabolic" velocity. If left to themselves, at the time of the collision the star would have a velocity 1/100 that of its "parabolic velocity" which if of the mass of our *Sun* would be around 6 km per second—the velocity of the *cloud* being around 600 km per sec. In the case of the star *after* encounter its space velocity would be *increased* by the 6 km. If it had been a normal M-type star with a space velocity of 34 km the planetary nebula resulting would have a velocity of 40 km. I do not know the mass of an average M-type star but it cannot differ widely from a normal G-type, probably somewhat less. We will probably not be far wrong if we assume the parabolic velocity to be 50 km for the M-type forerunner of the novae and planetaries. If this is correct then the increase of 11 km of the planetaries would call for a cloud approximately 1/50 the mass of the star.

If the mass of the cloud were *equal* to that of the star, its velocity at collision would be *half* that of its parabolic velocity or 250 km, in addition to its own original space velocity of 34 km or a *total velocity* for the planetary of 284 km.

If the mass of the cloud were many times that of the star, its velocity would be increased fantastically!

We thus see that if the space velocity of the cloud did not differ greatly from zero, the increase of 11 km of the planetaries confirms the assumption of a comparatively small mass for even the stabiiized planetaries and justifies confidence in much smaller masses of cloud for the ordinary transient novae, conclusions which resulted from other evidence and considerations. On the other hand this agreement practically establishes essential rest for the clouds of cosmical matter.

If the increase of 11 km is not due to the conditions treated but to *combinations of very different conditions* it can only be said that of them we have no knowledge and cannot therefore discuss such a contingency. Nor does it seem called for in view of the very satisfactory way in which assumption has agreed with observation and known physical processes.

In conclusion we may say therefore that Planetary Nebulae, Wolf-Rayet stars, and ordinary transient Novae are to be classified together not as nebulae, of *early* type in the orthodox evolutionary sequence, but as a sub-class of M-type which might be designated as M_p-type.

Villa Gral. Mitre (Totoral), Córdoba, October 22, 1948.

Russell W. Porter—An Appreciation*

By KNOWLES A. REYERSON

With the passing of Russell W. Porter on February 22 of this year amateur astronomers everywhere lost a warm-hearted friend and talented leader. He has been rightly referred to as the amateur's "patron saint." His contributions to both amateur and professional astronomy have already been well recorded in the several articles that have appeared since his death. Albert G. Ingalls, the second member of the team that popularized telescope making, and the one best qualified to record its history, has portrayed Russell Porter and his contributions in his excellent articles in *Scientific American;* the Scanlons in *Sky and Telescope;* and Oscar Marshall in *Popular Astronomy* have added personal accounts that high-light the picture. In volumes before his death his aid and inspiration to professional and amateur astronomers were recorded by Pendray in "Men, Mirrors, and Stars" and by Waldron in "Americans." These accounts, together with the several editions of our "bible," "Amateur Telescope Making," are lasting records to which I can add but little.

The thousands of telescopes, the numerous telescope making societies and groups, and meetings such as we are holding here today, are lively testimony to his inspiration. And finally the naming of a lunar crater for him by the British Astronomical Society as a result of a suggestion of one of our leading amateur moon observers, David Barcroft, here with us today, aided by Ingalls, is evidence enough of the permanent place that Russell Porter holds in the annals of astronomy.

However, many requests for information about him and his many-sided character continue and the request of your program chairman for some of these personal side-lights was difficult to refuse, though equally difficult to carry out. Of necessity the remarks are personal.

My own acquaintance with Russell Porter began many years ago at his old home in Springfield, Vermont. It was at one of the early telescope makers' round-ups at "Stellafane," the hilltop observatory near Springfield, which he and the first small group he organized developed into a substantial observatory on land he gave for the purpose. I was then in Washington in charge of foreign agricultural exploration, an occupation that permitted little in the way of continuous work on telescope making. An explorer himself in the Arctic, he was still one at heart and we had this in common over the years as well as an initial interest in astronomy.

I have been raised as a boy in Pasadena, living a portion of the time within a block of the Mt. Wilson shops where the 60-inch telescope was nearing completion and the 100-inch was in its early stages. Rus-

*Read at the Western Amateur Astronomical Congress held in Los Angeles, California, in August, 1949.

sell had the same generous interest in young folk that the astronomers of Mt. Wilson had in my boyhood. I look back almost with consternation at the amount of time I was under foot asking endless questions around those shops. It was a stimulating period in astronomical circles for the first early results of the Snow telescope and the 60-foot tower telescope were coming in. Foreign astronomers, together with those from our own great observatories, were visiting the mountain and the shops.

Public lectures were frequent, for Dr. Hale believed in keeping the public informed on developments and in sharing the exciting new discoveries. Pasadena was a small town then, and the observatory was its pride and joy. It was easy for even a boy to come to know Dr. Hale, Drs. Richey, Ellerman, St. John, Fath, as well as the shop staff. The head of our small stargazing group, the Santa Fe Railroad agent, W. P. Hoge, was asked by Dr. Hale to become custodian and observer's assistant on the 60-inch, a position he accepted and held for many years, adding another warm friend of the amateur to that splendid staff. In coming to Pasadena to be associated with the projected 200-inch telescope, Russell found a congenial atmosphere toward the amateur already awaiting him.

The early meetings at "Stellafane" in Vermont brought amateurs from as far away as Michigan; then as in more recent years Russell was the center of the sessions. He took an interest in each telescope brought by a hopeful maker, who never failed to receive a word of encouragement, praise, or both.

My return to California a few years after Russell came to Cal Tech permitted close association with his many interests. Through him I met many of the amateur pioneers already doing outstanding work—H. Page Bailey, of Riverside, maker of the first Schmidt telescope in the United States and here attending this meeting today; the Lowers, father and son, of San Diego, also builders of Schmidts and exquisite telescopes; Byron Graves, who died a week after Russell's death, and many others. His was an infectious enthusiasm and interest, a veritable virus that spread wherever he went.

He had a lively interest in people; he was a great sharer, eager to demonstrate the joys of accomplishment and share enthusiasm whether to a boy or a distinguished astronomer. He was always ready to help. He not only helped and inspired but pushed you into doing things; his beratings at sluggishness on mirror production were fun to receive. He had much good humor and an impish persistence.

Through his unparalleled drawings of the 200-inch reflector and the 18-inch and 48-inch Schmidt telescopes at Palomar and the cutaway drawings of the intricate mechanisms related to them and through his many sketches in "Amateur Telescope Making," his abilities in this field are well known. However, his general talents as an artist are not so well known.

He was an artist to the tips of his fingers, whether he worked with pencil, crayon, water color, or oils. He was skilled at portraitures; those of you who have ever visited "Stellafane" are familiar with the series of portraits of all the original group there that line the walls of the observatory. While in the Arctic he became greatly interested in the Eskimo types he met there, and the series of portaits that resulted from these studies has drawn much favorable comment from those privileged to see them.

He was fascinated by color whether in the Arctic, along the coast of Maine, the deserts of California, or farther afield in Mexico and the Mediterranean. The play of sunlight on ice, sand, water, trees, rocks, and mountains, fascinated him and he eagerly caught it on paper for others to share. It was a privilege of mine to have shared the desert of Southern California with him. His fingers would fairly itch to catch on his sketching pad the marvelous changing color.

Music also had its place in his life. Ingalls has referred to it in his article, and of his special love for Beethoven. He liked to compose and had a small piano alongside his bed. I dropped in to see him once when his heart had rebelled at his strenuous pace and he was temporarily laid up. He was at work on a musical score, and I facetiously asked if he were working on the "Music of the Spheres." Quick as a flash, with a twinkle in his eye, he answered, "Well, I'm pulling 'em out of the air!"

He also tried his hand with success at sculpturing. This is especially evident with some of his earlier sundials, but he did not follow it up as he had his painting. He did enjoy caricaturing and he modelled several that Ferson cast in brass. One called "The Telescope Nut" sits on my desk—a typical amateur seated on the ground peering up through the eyepiece from an anything but comfortable posture.

Russell Porter's contribution to the war is less well known because so much of it was highly secret. He had been engaged in optical work for the Bureau of Standards in the first World War, and was eager to help when the second one broke out. This meant temporarily laying aside work on the 200-inch telescope. His uncanny abilities to express in a clear drawing the cutaway appearance of intricate mechanisms yet to be built brought immediate calls for his help in the development of new and secret weapons. This involved work both at Cal Tech and at the Navy testing grounds at Inyokern, and along the coast as well. He was especially engaged in drawings and designs for rockets and rocket launching devices for land and seacraft, fuses, and even wind tunnels. Most of this work is still restricted and information about it is of necessity limited. I have brought over a few samples of his work that have been released, and you would recognize the hand of the master even if the familiar initials of R.W.P. were not in the corners. During this war period he worked with Dr. R. L. Richards, physicist of the

USDA Salinity Laboratory at Riverside to whom I am indebted for information of their activities.

He also made a major contribution to the war effort in the program worked up by himself, Ingalls, and Ferson of Biloxi, Miss., whereby complicated roof and other complicated types of prisms needed in range finders and other instruments were manufactured by a select group of amateurs. This was at the beginning of the war when the large optical companies had not solved the problem of mass production and the supply of prisms was far below the demand. This story has been well told by Ingalls in the *Scientific American*. It is a bright page in the story of the highly critical period at the beginning of the war. Some 35,000 prisms were made by the group selected and trained by the team of Porter, Ferson, and Ingalls.

He was never one who cared for credit for what he had done; he was one of that happy group aptly described by Robert Service who "did things for the doing, letting babblers tell the story." But the evidence of what he did and of the fun he gave to others is here today in this meeting, and in these exhibits. We would not be here today if it had not been for Russell Porter. He would have enjoyed being here.

No tribute to Russell Porter would be complete without a tribute also to his wife, Alice Porter. As in so many cases of successful men it is impossible to estimate the contribution made by a sympathetic and ever understanding helpmeet. Her home was always open to the countless visitors known and unknown who turned up at all hours of the day or night. There were endless cold meals when work kept Russell away, endless extra meals when visitors were brought home unexpectedly. There were breakfasts before daylight to get trips underway, and late snacks and coffee after all-night star gazing. Gatherings were held at his home, musical as well as astronomical. In all these, Alice Porter unselfishly shared her husband and her life, and for which we all owe her a debt of thanks and warm appreciation.

It is hard to believe him gone, but he has left a happy kindly influence widely spread. We miss that roguish, boyish grin and that mischievous twinkle in his blue eyes, for he never really grew up. It is the way he would want to be remembered, that the mention of his name would start smiles and bring forth chuckles.

Ours is a fortunate heritage of a great companion and a warm hearted friend. He has opened the eyes of thousands of us to the beauty of the world around us and also to that above and beyond our world. His jovial memory will go with us through the years ahead.

Through such organizations as this one meeting here we can help pass on to others something of the privilege that has been ours, and of the pleasure and understanding that he has brought us through optically (if not literally) moving the heavens closer to the earth.

Agricultural Experiment Station, Davis, California.

On the Possibility of Estimating the Figure of the Moon from the Uniformity of the Lunar Craters

By T. MURAKAMI

Survey of the Problem

It is a well-known fact that the moon is not spherical and that the greatest diameter is directed towards the earth. It seems necessary to us to explain the physical libration and the perfect coincidence of the periods of the moon's revolution and its rotation. However, we find only very few discussions heretofore made as to the figure of the moon, among them may be cited here that of Hayn and that of Hansen. The former concluded that the equatorial diameters of the moon differ about one-third of a mile[1], while the polar diameter is fully a mile less than the shorter of these. The latter has introduced in his lunar theory an empirical periodic term supposed to be due to the difference between the center of mass and the center of figure of the moon.[2] He concluded that the center of gravity was situated at a distance of 60 km from the center of figure. Unfortunately, however, as Newcomb has referred to the conclusions of Hansen as "curious" ones, few have given attention to them. The only reason why Newcomb had not accepted them is supposed to be that the problem of the figure of the moon must be very difficult of either proof or disproof. (Recently Professor H. Jeffreys has made a thorough theoretical investigation as to the moon's figure combining all the available data in celestial mechanics, but unfortunately I have no opportunity of reading his original papers as yet.)

Uniformity of the Lunar Craters

It appears possible to me to find an observational approach to this problem by observing the lunar craters telescopically and also by photographs of the moon. The marked regularity of the form of the lunar craters is evident, and I think that it is not unreasonable to assume the lunar craters to be almost perfectly circular on the surface of the moon. As to the cause of such uniformity, on accepting the hypothesis of the craters of volcanic origin, I assume that, as the difference of the geological structure of the surface may be supposed to be negligible as compared to the catastrophic eruptive force, the craters must have been formed to be circular in the equipotential planes of their locations.

There is a broad diversity in the lunar craters as to their dimensions, suggesting their complex origins. Excepting the greater ones, properly called the walled planes, and on the other hand, also the smaller ones supposedly of meteoritic origin,[3] I have measured only craters of moderate sizes on the photographs of the moon to obtain the inclination of the moon's surface to the line of sight.

Measurements

As to the photographs of the moon, I have made use of them collected in the *Annals of the Harvard College Observatory*, Vol. 51, 1903, published by E. C. Pickering. I have measured 231 craters in all. The plates measured are shown in the following table.

TABLE I

The Plates Used for the Measurements

Plate	Radius of the Moon's Disk (ρ_0) cm	Available Part	Number of Measured Craters
1 A	20.00	Greater part, except limb	13 (8)*
2 A	19.70	Greater part, except limb	7 (6)
3 B	18.90	Lower right, comparing with 3A	17 (12)
4 B	18.50	Upper right, comparing with 4A	16 (10)
5 A	19.28	Right half	17 (9)
6 A	19.93	Right half, comparing with 6B	32 (11)
8 A	19.12	Not so suitable, in general	37 (17)
9 E	18.90	Greater part	14 (7)
11 E	18.13	All	13 (5)
12 E	19.60	Comparing with 12A	25 (14)
13 E	20.00	Comparing with 13A	14 (11)
14 E	21.10	Except limb, comparing with 14A	9 (7)
15 E	19.57	Except limb, comparing with 15A	6 (6)
16 E	19.28	Comparing with 16A	12 (5)

*The figures in the parentheses are the number of craters utilized for reduction.

In each crater utilized here, I have measured the following quantities to the tenth of one millimeter.

(i) Distance of the crater from the center of the moon's disk (ρ), or from the limb ($\rho_0 - \rho$).

(ii) The greater diameter of the crater ellipse (α), taken in the perpendicular direction to the moon's radius.

(iii) The smaller diameter of the crater ellipse (β), taken in the direction of radius.

Cautions were taken to make the measurements as accurate as possible omitting the apparently deformed and collapsed craters, and following out the same plan from the beginning. Each measurement of the dimension of the crater ellipse was made always regarding the inner limb of the crater.

After measuring the above quantities, the ratio of the distance to the radius

$$\rho : \rho_0 = \kappa,$$

or otherwise

$$(\rho_0 - \rho) : \rho_0 = 1 - \kappa,$$

and also the ratio of the two diameters of the ellipse were calculated.

Parts of the fundamental table which I have used in my investigation are shown in Table II, as a sample for reference, giving the measured values in their original figures and also the computed values of other quantities some of which may be explained subsequently.

TABLE II

THE MEASUREMENTS IN PLATE IA ($\rho_0 = 20.00$ cm)

No.	Name	$\rho_0 - \rho$	$1 - \kappa$	$\cot \phi$	α	β	β/α	$\tan \psi'$	a/b	Wt.
1	Firmicus	2.87	0.143	1.662	6.35	3.3	.519	1.647	0.99	3
2	Taruntius	6.63	0.332	0.898	6.3	4.5	.714	0.981	1.09	3
3	Condonet	1.85	0.095		8.7	3.8	.437			2
4	Picard	4.43	0.222	1.283	2.8	1.8	.643	1.191	0.93	2
5	Proclus	6.09	0.304	0.967	3.4	2.3	.677	1.087	1.12	2
6	Next one to 7	5.43	0.272	1.062	4.4	2.8	.637	1.210	1.14	2
7	Macrobius	5.89	0.294	0.997	7.5	5.2	.693	1.042	1.04	4
8	Bruckhardt	3.25	0.163	1.530	6.5	3.5	.539	1.563	1.02	2
9	Berosus	1.37	0.067		8.8	3.5	.398			2
10	Bernouilli	2.36	0.118	1.872	5.3	2.6	.491	1.774	0.95	3
11	Geminus	2.92	0.146	1.643	10.2	4.7	.461	1.894	1.15	4
12	Messala	2.20	0.110		14.6	6.6	.453			2
13	Mercurius	1.22	0.062		7.9	2.8	.354			2

Here the weight (from 5 to 1) means the accuracy of the measurements of the two axes of the crater ellipses.

REDUCTION AND THE DERIVED RESULT

If we assume the section of the moon through a plane including the line of sight to be an ellipse of axes a and b, and the coordinates of a crater M to be (x, y), then we can easily derive the relation[4]

$$\tan \phi = y/x \cdot (a/b)^2.$$

Furthermore, considering the minor auxiliary circle to the ellipse, we have

$$x/x' = a/b$$

and

$$\tan \psi' = y/x',$$

so that

$$a/b = \tan \phi / \tan \psi' \qquad (a)$$

Here ϕ and ψ' are given by

$$\phi = \cos^{-1} (\beta/\alpha)$$

and

$$\psi' = \sin^{-1} \kappa$$

where β/α and $\kappa = \rho/\rho_0$ are given in our measurements.

We have computed a/b for each crater having κ between 0.5 and 0.87 (ψ' between 30° and 60°) the craters near the limb or the center of the image of the moon being rejected as they are considered ineffective for the derivation of a/b.

Taking averages of a/b and plotting, there results practically a normal distribution curve from which the mean value of a/b is determined to be 1.02 or 1.03.

To derive more rigorous conclusion, I have treated the measured values by the method of least squares. As the measurements were made with the weights, there are 327 values of weight in total. The weighted mean is secured as 1.018 with the probable error of 0.0046, so that we may take the most reliable result as

$$a/b = 1.02 \pm 0.005 \text{ (p.e.)}.$$

It means that the radius of the moon directed toward us is some 1/50 parts (about 35 km) longer than the axes perpendicular to the line of sight. (The difference of the polar and equatorial radii is overlooked here.)

In Conclusion

I wish to execute more detailed measurements with the more enlarged lunar photographs if possible, taking into consideration the libration, the local inclination of the surface, the direction of sun-light and other factors to minimize the deviations of the result.

In addition we may mention here that the original idea was explained at the colloquium of the Astronomical Department, Kyoto University, on December 8, 1931, before Dr. I. Yamamoto, Dr. T. Araki, Professor J. Ueta and others; also the report here given has been read at the Annual Meeting of the Astronomical Society of Japan, Tokyo, on May 1, 1949. Hearty acknowledgement is due to Professor T. Matsukuma of Tokyo University as to the suggestions then given for future work.

References and Notes

[1] Russell, Dugan and Stewart, *Astronomy*, Vol. I, p. 170, 1927.

[2] *Darlegungen der theoretischen Berechnung der in den Mondtafeln Angewandeten Störgen, Abh. der K. Säch. Gesell. d. Wissenschaften*, Vol. vi, pp. 175, 474-479.

[3] The origins of lunar craters and other surface structures may be discussed separately.

[4] The equation of the ellipse is given by

$$y^2 + (b/a)^2 x^2 = a^2 (b/a)^2,$$

and differentiating

$$2y\,dy + 2x\,(b/a)^2\,dx = 0.$$

Also $\tan\phi = -dx/dy$, we have $\tan\phi = y/x \cdot (a/b)^2$.

Astronomical Institute, Hiroshima University, Hiroshima, Japan.
July 16, 1949.

The Planets in December, 1949

By RAYMOND H. WILSON, JR.

Note: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. The sun will be more than 23 degrees south of the equator during most of this month. It will be farthest south at the Winter Solstice, which will be reached at 10 P.M. on December 21, making this the shortest day of the year.

Moon. The phases of the moon will occur as follows:

Full Moon	December	5	9 A.M.
Last Quarter		12	8 P.M.
New Moon		19	1 P.M.
First Quarter		27	1 A.M.

Perigee will occur on December 17.

Evening and Morning Stars. Jupiter and Venus will be conspicuous in the evening twilight; while Mars and Saturn will be rising shortly after midnight.

Mercury. Mercury might be glimpsed low in the southwest within a half hour after sunset during the last few days of the month.

Venus. Although Venus has passed its greatest elongation east, it will be increasingly conspicuous in the southwest twilight. This is both because of its northward motion, and because it will stand at greatest brilliancy for this elongation on December 26.

Mars. In close company with Saturn, Mars will be moving rapidly eastward between Regulus and Spica. On the morning of December 13 the moon will pass only a few minutes to the north of it.

Jupiter. Jupiter and Venus will be fellow-travellers in the southwest twilight, especially during the first half of the month. On December 7 Venus, the brighter, will pass 2 degrees to the south of Jupiter in their apparent eastward motion.

Saturn. Saturn will stand westward of Mars during this month, and will be actually stationary in right ascension on December 31. Shortly after midnight on December 13 it will be seen just a few minutes north of the quarter moon.

Uranus. On the evening of December 24 Uranus will be in opposition to the sun at about a degree north of μ Geminorum.

Neptune. Neptune will be moving southeastward at about a degree west of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.,
October 1, 1949.

Asteroid Notes

By HUGH S. RICE

There are three more fairly bright asteroids available in the 1949 set of ephemerides; and we give their positions this month. 52 EUROPA, of magnitude about 9.7, is at the Orion-Taurus boundary; 109 FELICITAS, of magnitude 10.1, is in Auriga, near the star Theta; and 14 IRENE, of magnitude 9.5, is in northwest Gemini.

These should be observable in a small telescope, if plotted on the right kind of stellar chart. An ideal chart for this would be the old Argelander series, long out of print. When the chart shows stars as faint as the planet, identification may be immediate; but if the stars on the chart do not quite reach the asteroid's magnitude, the observer usually has to wait for a day or more, to find one of the points of light moving between observations, the moving point being the minor planet. It is a matter of regret that the two new star charts—the Skalnate-Pleso and the French charts by Brun—do not go down to a faint-enough magnitude for asteroid work; however, the charts were not designed for our type of observation.

Our 50-mm Zeiss glass cannot show the magnitudes above indicated for the asteroids. The faintest magnitude discernible appears to be 9.2. The theoretical limit for 50 mm is supposed to be 10.5, and the difference here of more than a magnitude is because our glass is a prism binocular and designed primarily for terrestrial use. The shorter focus and presence of the prisms are two factors preventing the attainment of the ideal faintest magnitude.

We have word from the New York office of Carl Zeiss that before long we may expect new astronomical goods from their Jena factory. Binoculars have been arriving already. 8000 men are now at work at production of these materials. Probably the first new Zeiss telescope to arrive on the American market is a 63-mm instrument. While this is a small telescope, the report is that it will be equatorially mounted and on a pedestal-type of mount, with circular base. This statement is somewhat surprising, but it is said that an altazimuth mounting is also available. A Huygens 40-mm ocular, a 16-mm, and an orthoscopic 10-mm, are to be supplied, allowing magnifications of 20 to 84. A 6-mm ocular is also being made. (We have found the Zeiss oculars very superior in quality.) The focus of the objective is 84 cm, the glass being a 2-lens type, with greatly reduced secondary spectrum, likely corresponding to their former AS objective. Several accessories are supplied, such as a revolving eyepiece arrangement, eyepiece prism, sun-projection screen, Herschel sun-prism, zenith prism, etc.

ASTEROID EPHEMERIDES

For 0^h U.T. Equinox 1950

52 EUROPA

1949-50	α h m	δ ° ′
Nov. 28	5 44.7	+14 42
Dec. 6	5 38.3	+14 45
14	5 31.4	+14 51
22	5 24.4	+15 2
30	5 17.8	+15 17
Jan. 7	5 11.9	+15 36

109 FELICITAS

1949-50	α h m	δ ° ′
Nov. 28	6 7.9	+38 20
Dec. 6	6 1.6	+38 55
14	5 53.5	+39 15
22	5 44.7	+39 17
30	5 36.6	+39 1
Jan. 7	5 30.3	+38 30

14 IRENE

1949-50	α h m	δ ° ′
Dec. 6	6 35.4	+23 40
14	6 28.4	+24 16
22	6 20.1	+24 52
30	6 11.2	+25 26
Jan. 7	6 2.4	+25 58
15	5 54.6	+26 25

Hayden Planetarium, American Museum of Natural History,
New York, October 22, 1949.

Occultation Predictions for December, 1949

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1949	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
Dec. 3	τ Arie	5.2	21 52.6	+1.0	+3.0	3	22 21.5	−1.3	+0.5	304
8	BD+27°1337	6.4	3 0.0	−0.8	+1.5	84	4 14.2	−1.5	+0.8	277
9	λ Canc	5.9	9 24.9	−1.2	−2.0	128	10 38.5	−1.2	−1.5	282
31	ζ Arie	5.0	4 30.2	−1.4	−0.7	77	5 45.9	−0.9	−0.7	249
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Dec. 1	ζ Pisc	5.6	3 49.7	..	..	121	4 19.3	..	..	162
1	BD+6°175	6.5	3 52.4	..	..	123	4 19.4	..	..	160
8	BD+27°1337	6.4	2 48.7	0.0	+1.8	68	3 49.8	−1.0	+0.7	288
9	λ Canc	5.9	9 11.5	−0.8	−4.3	167	10 2.3	−3.1	+1.6	241
11	107 B.Leon	6.3	7 6.2	..	..	34	7 17.9	..	..	15
28	171 B.Pisc	6.3	4 39.8	−0.8	+0.1	53	5 48.4	−0.4	−0.6	248
31	ζ Arie	5.0	3 58.2	−2.1	−0.1	79	5 23.1	−1.6	+0.5	235
Occultations Visible in Longitude +98° 0′, Latitude +31° 0′										
Dec. 8	BD+27°1337	6.4	2 36.0	+0.1	+1.1	82	3 36.6	−0.5	+1.0	271
11	107 B.Leon	6.3	6 32.7	−0.6	+1.2	87	7 35.9	−1.2	−1.0	318
25	70 Aqar	6.2	3 41.0	+0.4	+2.3	6	4 20.8	−0.6	−2.1	287
28	171 B.Pisc	6.3	4 35.2	−1.5	−0.8	81	5 43.3	−0.6	+1.1	215
31	ζ Arie	5.0	3 45.6	−3.5	−1.5	106	4 54.8	−1.7	+3.5	201
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Dec. 1	ζ Pisc	5.6	2 29.2	−1.5	+1.9	57	3 52.2	−1.3	+2.1	218
1	BD+6°175	6.5	2 30.3	−1.5	+1.9	58	3 53.5	−1.3	+2.1	218
3	36 Arie	6.5	3 19.2	−2.5	+0.6	104	4 10.4	+0.2	+3.8	183
7	49 Auri	5.0	13 49.1	−1.6	+0.2	53	14 30.0	+0.8	−2.9	334
11	107 B.Leon	6.3	6 43.3	..	..	42	7 6.3	−1.1	−3.6	354
11	37 Leon	5.7	14 15.8	+0.2	−3.6	174	15 3.9	−2.5	−0.4	257
28	171 B.Pisc	6.3	4 3.3	−1.3	+1.7	35	5 23.8	−1.5	−0.2	248
31	ζ Arie	5.0	2 56.9	−1.3	+2.2	48	4 23.4	−2.2	+1.2	246

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In the following Notes three fireballs are discussed. In order, a good solution was derived for the first, a fair one for the second, and a very poor, partial one for the third. Nevertheless, it seems that even cases like the last should be put on record, as they may be of interest to future investigators. I should add that very many fireballs, on which we have from two to scores of reports, remain here unsolved due to lack of assistance. Some indeed have had preliminary work done on them, and of course many cannot ever be solved in a complete or satisfactory manner, due to poor data.

It is still a matter of surprise to us that even the brightest meteor, over many parts of the country, brings in so few reports in many cases. Also that so few people seem to know anything about any of the constellations or the brighter stars. Hence most who do report are unable to use the stars for reference, which of course would make their reports many times more accurate. There is certainly a wide field for popular education along these lines. I suggest that local

astronomical societies, besides having lectures, should have outdoor meetings at intervals for constellation study only.

OREGON FIREBALL OF 1946 AUG. 26/27; A.M.S. No. 2318

The 12 observations of this fireball, seen at 8:05 P.M., P.S.T., were as usual collected by Prof. J. Hugh Pruett and sent to me. Although the number is not large, yet the solution is far more accurate than usual, due to circumstances which will be mentioned. Indeed I consider it one of the best paths I ever computed.

First, the sub-end point E_1 is defined extremely well by 4 azimuths which cut practically in a point. Again D. C. Livingston at Glide, S12, states that the object went through his zenith. H. R. Russell at S2, WNW 3¼ miles from Modoc Point, saw it "pass between the pointers of the Big Dipper, closer to the lower . . ., thus giving an excellent point on the path. Mrs. L. W. Van Fleet at S8, Sherwood, said that the path passed over Antares and ended near Epsilon Sagittarii. The point E_1 is beautifully fixed by the azimuths of W. Jones, Gold Hill, S1; Mrs. C. O. Dich, Portland, S5; L. A. Wood, Medford, S6; and S12 already mentioned. The slope was also well described by several and permitted me to make a correction to the estimated altitudes from Eugene, S4, and S5. The end height, based upon 8 observations, comes out 57 ± 12.7 km. While the report of S8 would indicate, and from S1 positively states, that the fireball started farther to the S.W. and hence higher than the beginning height given here, namely 86 km based upon the excellent observation from S8, the latter is the first identifiable point and hence must be the point used in computing the data to follow. The projected path is then 229 km. The slope of the path is excellently checked by the very accurate observation of S2, and also by one from S4 and one from S7, the latter by Dr. C. L. Perkins, Medford. We find the true path, *i.e.*, from where it was first seen from S8 to the end point, to be 231 km long. We have usable estimates of duration by 7 persons. When corrected in a couple of cases for the portion of the path not seen, we get the average value of duration as 5.53 ± 1.40 seconds. This would give an observed velocity of 41.7 ± 16.5 km/sec, which seems a little high, considering the time of day, etc. However, we can never have high confidence in velocities so determined, as estimates of duration are notoriously difficult to make with accuracy. The usual varieties of colors are reported but yellow predominates, while some say it became redder near the end. No sounds were heard. As most express its apparent diameter in terms of the Moon, it must have had an apparent disk: 10′ would be an average. There is enough evidence, though reported by a minority of observers, to indicate sparks or pieces were thrown off. A 5° train is reported by some, which quickly disappeared. I infer that this small train really trailed immediately behind the head and certainly did not last along the whole path.

A striking thing is that, when the zenith correction for parabolic heliocentric velocity is applied to the altitude of this fireball, we find its radiant 5°+ below the horizon. In other words but for the Earth's additional gravitational pull, which curved the path towards us, it would have missed the Earth completely. This perhaps may also account for the fairly high end height. The obvious uncertainty in the observed velocity scarcely would justify us in calculating anything but a parabolic orbit. The usual data follow.

Date	1946 Aug. 26.67 G.M.T., Aug. 27.17 G.C.T.
Sidereal time at end point	275°.0
Began over	$\lambda = 124°\ 18'$ W, $\phi = 42°\ 41'$ N at 86 km
Ended over	$\lambda = 122°\ 02'$ W, $\phi = 43°\ 57'$ N at 57 ± 12.7 km
Length of path	231 km
Projected length of path	229 km
Duration	5.53 ± 1.40 sec
Observed velocity	42 ± 16 km/sec
Radiant uncorrected	a = 53°, h = 8°.4
Zenith correction (parabolic)	—13° 39′
Radiant corrected	a = 53°, h = —5°.3; $\alpha = 208°.8$, $\delta = -29°.7$

The elements of the parabolic orbit are:

$$i = 6°—$$
$$\Omega = 334°$$
$$\pi = 319°$$
$$q = 0.99 \text{ A.U.}$$

The radiant is A.M.S. No. 2318. No similar radiant is found in the von-Niessl-Hoffmeister Catalogue. However, the object may well be assumed to belong to the species of fireballs which have orbits not unlike the small asteroids having their perihelia within our orbit. It may be suggested to compare this radiant with A.M.S. No. 2279, that of the fireball of 1938 July 26, published in the June, 1940, POPULAR ASTRONOMY. Incidentally all the 1000± observations on the latter were later turned over to me by C. A. Federer and F. Watson, so that eventually I hope to get out a revised and more accurate solution for No. 2279. Much work, at intervals, has been done on it already but the mass of data is so great that the solution has never been finished, merely from lack of time.

In the case of the present fireball, we are under the usual great obligations to Prof. Pruett for gathering the data, which included sending follow-up letters and questionnaires to many observers, and to T. A. Scott for arranging the data, drawing the map, and determining the sub-end point. My own part consisted in the actual determination of the beginning point, the path, and calculating the orbit. Our sincere thanks go to the persons whose observations made the solution possible.

FIREBALL OF 1945 APRIL 19/20; A.M.S. No. 2319

On this date at 8:15 P.M., E.S.T., a splendid fireball was seen from in or near Washington by at least 3 observers and possibly by another, from Pennsylvania by 2, and from Long Island possibly by one, giving us at most 7 reports. After several attempts, a fairly satisfactory solution was reached, but only by omitting the Long Island observation, which though coincident in time (provided the observer used D.S.T. as did the others though he does not say so) would give a path which at closest could not come within 160+ miles to the east of the path we compute from the rest. Almost certainly he saw another fireball, probably a companion of the one we compute, as the motion was in the same general direction.

Our solution is based upon 4 reports which give angular coordinates, 3 being in or near Washington, S3, S4, and S5, and one, S2, from Ephrata, Pa. The latter by T. R. Sprecher, is obviously the key report. If we used his directly estimated altitudes and h_η, no solution could be made, but fortunately he gave two checks. First that the path made a 40° angle with the horizon, second "Path originated near Beta Orion and apparently went below the horizon near Alpha Canis Major." Using the celestial globe, and in view of his dead-reckonings, it is quite clear that

he meant α and β Orionis. Also his horizon was a small hill, so h_2 is assumed as 5° which fits the whole well. The observation from S3, Arlington, Va., Miss J. C. Verby, also had h_1 decreased to fit the data given by her for Δa, h_2, and the slope of the path. S4, north-edge of District, by Lt. E. Drum, USNR, and S5, near Naval Observatory, by J. A. Larrivee, were used without modification.

The fireball was bright enough to show a disk estimated at 1/10, 1/2, and 1/2 the Moon's diameter by the Washington observers. It was probably yellowish in color. The description of the train is contradictory, but nobody saw it for over 5 seconds. The usual data follow.

Date	1945 April 19.55 G.M.T., April 20.05 G.C.T.
Sidereal time at end point	149°
Began over	$\lambda = 78°\ 10'$ W, $\phi = 39°\ 45'$ N at 86 ± 18 km
Ended over	$\lambda = 77°\ 40'$ W, $\phi = 39°\ 07'$ N at 22 ± 5 km
Length of path	56 km
Projected length of path	44 km
Duration	$3.38 + 0.82$ sec (4 observers)
Observed velocity	17 km/sec
Radiant uncorrected	$a = 148°$, $h = 38°.6$—; $\alpha = 68°$, $\delta = +65°$
Zenith correction (parabolic)	—3°.0
Radiant corrected	$a = 148°$, $h = 35°.6$—; $\alpha = 61°$, $\delta = +64°$

No fireball radiant is found in the von Niessl-Hoffmeister Catalogue for this date near this position. However, No. 120, seen on 1912 April 7, has a radiant at $\alpha = 45°$, $\delta = +62°.5$. If allowance is made for shift, due to the different dates, perhaps they might have had an original connection.

As always we are greatly indebted to the persons who reported. Part of the preliminary work on this fireball was done by T. A. Scott, who was on our staff during the summer.

Fireball of 1943 Feb. 8/9; A.M.S. No. 3548

On the above date at approximately 9:15 P.M., E.S.T., a fine fireball crossed the state of Georgia from north to south. Thanks to Mr. Nathan Levy of Atlanta, who himself sent in a full report and who kindly acted as our agent in gathering information, in all some 27 reports were obtained. These were turned over to Miss Edith Reilly, then on our staff, and she attempted a solution. The results were laid aside for further study, and were recently handed over to T. A. Scott. He too found a good solution impossible, so in turn I have tried to find a path satisfying the data. This apparently cannot be done, so I am placing on record the little in which we can have some confidence.

The fireball probably was first seen or perhaps started over a point near λ 82° 45′ W, $\phi = 33°\ 44'$ N, at a height of about 77 km. It then took a course towards azimuth 20°, therefore to the west of south, along a path of low inclination probably ending over a point near λ 84° 39′ W, ϕ 33° 50′ N, the projected path being then 463 km long. The few observers who attempted to give anything like exact alitudes and azimuths are all near the northern end: we have no such usable observations well to the side of the path. Nevertheless, we cannot ignore those who insist that the object ended in the south or south-west, which is true of 5 observers so situated that a much shorter and steeper path, indicated by the better observers, is impossible. All we can say about the end height is that it was doubtless low. The estimates of time of visibility vary from one to 12 seconds, most however being between 1 to 4: evidently much too short. The object seems to have had a disk; 5′ for the diameter would be a fair estimate. Its color varied according to the observer's impressions, but possibly there is more

agreement on greenish-white. It evidently was very bright. There was at least one brilliant flare or burst, with small fragments being thrown off. This occurred in the earlier part of its path.

Near Graymont, in Emanuel Co., an observer with two companions reported hearing a very heavy explosion and rumblings, following the passage. The sounds were also very strong at Swainsboro, a few miles west of Graymont. Window panes were rattled from the concussion. These points are roughly 50 miles east of our projected path. There were no similar sounds reported by others.

It is a matter of much regret that no full solution can be made. Most of the computational work was done by Miss Reilly and nearly all the correspondence needed in securing the reports by Mr. Levy. To both sincere acknowledgements are given for their assistance, also to Mr. Scott for completely checking all that had been done formerly.

Flower Observatory of the University of Pennsylvania, Upper Darby, Pa., 1949 Aug. 29.

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

The Weatherford, Oklahoma, Meteorite (ECN = +988,358)*

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ABSTRACT

In this paper are given details concerning the discovery of an unusual irony-stone meteorite near Weatherford, Custer County, Oklahoma (equatorial coördinate number (ECN) = +988,358). There is some evidence that the specimen recovered is only a fragment of a much larger mass, but neither visual nor instrumental searches have led to additional recoveries. Consequently, the mineralogical and chemical investigations have necessarily been based upon the examination of the single specimen so far discovered, that found by Mr. A. B. Potter in 1926. On the basis of these investigations, which are detailed in the paper proper, the meteorite has been classified as a siderolite of class sideraerolite (S) and subclass mesosiderite (Sms).

1. *History and Descriptions.*—In 1926, Mr. A. B. Potter, while plowing a field on his farm about 7 miles NNW of Weatherford, Custer County, Oklahoma, turned up a heavy, dark, reddish-brown object with a surface "about as rough as a concrete floor." Potter's find had much the shape of a prolate ellipsoid of revolution. A vertical section thru the longest dimension of the mass had an approximately elliptical shape with a major axis of 18.1 cm. and a minor axis

*Read at the 12th Meeting of the Society, Los Angeles, California, 1949 September 6-8.

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‡Director, Institute of Meteoritics, University of New Mexico.

of 9.7 cm. A perpendicular vertical section thru the center of the mass had an approximately circular shape with a radius of 5 cm. The chief irregularity in both the ellipse and the circle was a slight flattening along the base of the specimen. The original weight of the mass was almost exactly 2 kg. Mr. Potter decided on the basis of its "unusual weight" that his discovery must be "a piece of old, rusty iron," and brought it in for examination to the hardware store of his brother, C. W. Potter, in Weatherford. Here the heavy object served for several years as a paperweight. Its true nature was first surmised in 1938 by Mr. Hal C. Hoberecht while he was a senior in the Weatherford High School. Mr. C. W. Potter presented the specimen to Hoberecht and for many months the latter attempted locally to obtain verification of his guess that A. B. Potter's find was a meteorite, but, possibly because of the unusual nature of the specimen, no one would confirm Hoberecht's surmise. Finally, in January, 1940, he broke the 2-kg. mass into a number of pieces and sent several of the smaller fragments to Mr. Carl Barnhart of the Wichita (Kansas) High School, to Dr. W. J. Stovall of the University of Oklahoma, and to the Smithsonian Institution. The nature of A. B. Potter's find was recognized at once by E. P. Henderson of the Smithsonian Institution, and, on February 13, 1940, Mr. Hoberecht sold 1431 gm. of his meteorite to that Institution. To date, however, no description or analysis of this irony-stone seems to have been published.

The Weatherford meteorite was brought to the attention of the Institute of Meteoritics of the University of New Mexico in November, 1945, when Mr. Hoberecht generously presented all of the meteorite remaining in his possession to the Director of the Institute. Mr. Hoberecht also kindly supplied all of the facts and part of the details concerning the possible existence of additional, larger masses of the Weatherford irony-stone that are given in the next section.

2. *Instrumental Search for Additional Masses of Weatherford.*—Both the flattened base of the 2-kg. mass (which could have been a plane of separation) and the fact that, according to Hoberecht, this mass shattered readily when struck with a hammer suggest that the Potter find is a fragment of a larger body. Some support for this view is given by the following reports of discoveries of additional larger masses that may possibly have belonged to the Weatherford fall.

According to Mr. Hoberecht, in the early 1920's, a large, heavy, dark rock was encountered in plowing a field approximately 3 miles due west of the spot where A. B. Potter found the 2-kg. mass. Two teams of horses were used to drag it out of the field and to deposit it on the edge of Horse Creek. Later it was noted that the creek bank had collapsed after a heavy cloudburst and that the big, dark rock had disappeared in the creek bed.

According to Mr. Alfred May, a farmer living about 4 miles west of the Potter farm, a heavy, black rock, weighing 25 or 30 lb., was plowed up in one of his fields in 1925 or 1926. Mr. May's attention was attracted by the unusual density of the mass and by the fact that it was unlike any other rock he had seen in the region. May's find was left in the field, however, and it was only after Hoberecht had sold part of his meteorite to the Smithsonian Institution that May recalled having discovered the larger mass. Unfortunately, he could not relocate it.

On July 8, 1947, Mr. Grover Leonard, a farmer living about 1½ miles SE of May, told a party from the Institute of Meteoritics that, in the early days of the WPA, a group of workmen engaged in leveling the yard at a district schoolhouse near his farm had uncovered a badly oxidized, 150-lb. mass superficially resembling the Potter find. Leonard believed that this mass had been

preserved as a curiosity in the cellar of the schoolhouse about 2 miles WSW of his farm, but a search conducted jointly by him and Institute personnel on July 8 and 9, 1947, failed to discover it.

Because of the apparent reliability of the witnesses responsible for the foregoing reports, and the physical characteristics of the only mass so far preserved from the Weatherford fall, the Institute of Meteoritics, in July, 1947, made a search with meteorite detectors in the areas where large masses were encountered in the 1920's. No meteorites were found in the course of this search. Furthermore, no additional surface finds have been made and reported by the scores of persons alerted by the Institute's survey in the Weatherford area. At the present time it must be presumed that the 2-kg. mass found by A. B. Potter constitutes the only recovered fragment of the Weatherford fall.

3. *Mineralogical Characteristics and Chemical Analysis.*—The Weatherford, Oklahoma, meteorite is an irony-stone, which, on the basis of mineralogical studies, is here classified as a siderolite, of class sideraerolite (S) and subclass mesosiderite (Sms).*

A polished section exhibiting the metallic phase shows that the nickel-iron in the mass coheres, but in a thin section the nickel-iron is separated from the stony phase. The rounded masses of nickel-iron consist of kamacite and schreibersite. There seem to be 2 types of nickel-iron masses in the meteorite: (1) structureless kamacite with schreibersite of all shapes; the schreibersite occurs

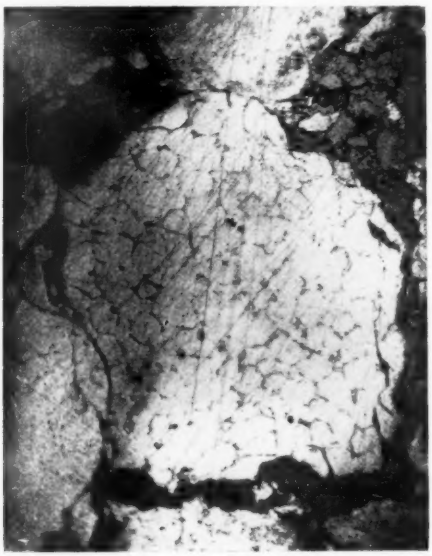

FIGURE 1
STRUCTURELESS KAMACITE WITH SCHREIBERSITE IN THE WEATHERFORD METEORITE (× 27:)

*Cf. Frederick C. Leonard's "A Simplified Classification of Meteorites and its Symbolism," *C.M.S.*, **4**, 141-6; *P. A.*, **56**, 437-42, 1948.

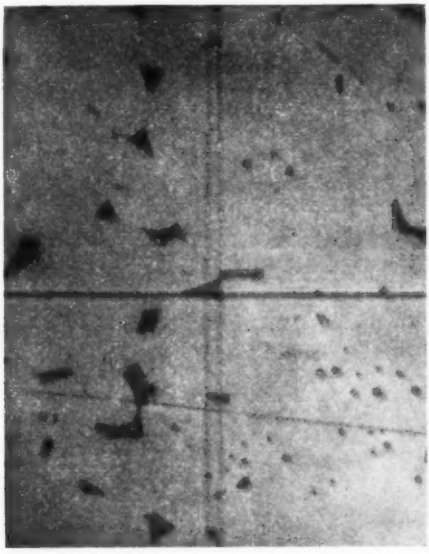

FIGURE 2
GRANULAR KAMACITE WITH SCHREIBERSITE ALONG BOUNDARIES IN THE WEATHERFORD METEORITE
(×11:)

as needles (or dots representing sections of needles), as rhabdites, as exceedingly irregular bodies, and as minute particles dispersed thruout the kamacite (Fig. 1); and (2) granular kamacite, in which most of the schreibersite is concentrated along the boundaries of the kamacite grains (Fig. 2). In the latter case, some minute grains of schreibersite occur within the kamacite grains, but otherwise the kamacite is structureless. It suggests an iron-phosphorus-nickel eutectic.

Etching with 5% Nital brings out no pattern. The lack of an etch test and the structureless kamacite suggest that the metallic phase is a low-nickel ataxite. The chemical analysis reveals a slightly higher nickel content than is consistent with low-nickel ataxites; however, the analysis has been checked.

Chemical Analysis of the Metal Phase of the Meteorite

Fe	89.82%
Ni	6.10
Co	0.48
P	2.69
S	0.56
Al	None
	99.65%

$$n = \frac{\text{Fe}}{\text{Ni}} = 14.72$$

$$m = \frac{\text{Fe}}{\text{Ni} + \text{Co}} = 13.65$$

The most striking feature of the chemical analysis is the extraordinarily high percentage of phosphorus.

As mentioned, the percentage of nickel is slightly higher than the generally

accepted values that have been compiled for low-nickel ataxites. It is possible, therefore, that the metallic phase represents a coarsest octahedrite and that the relatively small section includes only the kamacite band and does not show the taenite.

The stony phase of the Weatherford meteorite was studied by the thin-section and oil-immersion methods. The stony phase consists of badly altered enstatite (variety, bronzite) and olivine, with the former dominant. Both are considerably altered either to magnetite or, in some cases, to hematite. The magnetite is in sufficient quantities to show in the polished section.

The habit of the enstatite is elongate, intergrown in all directions, as tho it were fibrous. In some grains the enstatite extinguishes in a fan-like fashion; in others, the extinction is undulatory because of strain. The enstatite exhibits the usual pyroxenic cleavages, but, because of the habit, they are not well developed. Much iron has settled out from the melt as hematite (Fe_2O_3), and much iron has altered from the enstatite as magnetite (Fe_3O_4). The enstatite has the following indices of refraction: $\alpha = 1.680$, $\beta = 1.687$, $\gamma = 1.692$. Mg:Fe = 82:18.

The olivine in the stony phase is considerably altered to magnetite. The olivine has the following indices of refraction: $\alpha = 1.680$, $\beta = 1.701$, $\gamma = 1.720$. Mg:Fe = 78.5:21.5.

4. *Conclusion.*—The presence of both enstatite and olivine in this irony-stone justifies its classification as a mesosiderite (Sms). Its unusual characteristics are the extremely high percentage of phosphorus and the low-nickel (or possibly coarsest octahedrite) composition of the metallic phase.

Report on the 12th Meeting of the Society

JOHN A. RUSSELL, *Chairman, Program Committee for the 12th Meeting*
Department of Astronomy, University of Southern California,
Los Angeles, California

The 12th Meeting of the Meteoritical Society convened on the campus of the University of Southern California, Los Angeles 7, California, on Tuesday morning, 1949 September 6.

The following 20 members and a considerable number of guests were present at one or more of the sessions: A. R. Allen (Trinidad, Colorado), Carl W. Beck (Albuquerque, New Mexico), L. F. Brady (Flagstaff, Arizona), John Davis Buddhue (Pasadena, California), C. H. Cleminshaw (Los Angeles, California), W. D. Crozier (Socorro, New Mexico), Bernard J. Finnegan (Los Angeles, California), E. L. Forsyth (Fallbrook, California), Walter H. Haas (Albuquerque, New Mexico), Dorsey Hager (Salt Lake City, Utah), Arthur S. King (Pasadena, California), Lincoln La Paz (Albuquerque, New Mexico), Frederick C. Leonard (Los Angeles, California), P. J. McGough (Santa Barbara, California), Oscar E. Monnig (Fort Worth, Texas), A. M. Newton (Los Angeles, California), H. H. Nininger (Winslow, Arizona), Asbjörn P. Ousdal (Santa Barbara, California), John A. Russell (Los Angeles, California), and Paul E. Wylie (Los Angeles, California).

The meeting was called to order by President King and was opened with an address of welcome by Dean Tracy E. Strevey of the College of Letters, Arts, and Sciences of the University of Southern California. Then followed the presentation and discussion of some 27 papers, 5 of which (marked *) were read by proxy in the absence of their authors and 3 of which (marked † or *†) were presented by title only.

LIST OF PAPERS READ AT THE 12TH MEETING
(in the order of presentation)

Morning Session, September 6

*1. "The Mechanism of the Sounds from Meteors," Brandon Barringer and Harry C. Hart, The Pennsylvania Company, Philadelphia 1, Pennsylvania, and 21 Lilac Lane, Princeton, New Jersey. (Read by Dr. Leonard)

2. "Some Remarks on the Origin of Earthly Meteorites," Dr. Frederick C. Leonard, University of California, Los Angeles.

†3. "Azimuth Determinations in Meteoritics by Means of Time Readings," Dr. Lincoln La Paz, University of New Mexico, Albuquerque.

4. "Lunar Craters," Dr. Lincoln La Paz.

5. "The Collection and Identification of Air-borne Particles," Dr. W. D. Crozier and Ben K. Seely, New Mexico School of Mines, Socorro.

Afternoon Session, September 6

*6. "A Preliminary Comment on Micro-meteorites," Dr. Fred L. Whipple, Harvard College Observatory, Cambridge, Massachusetts. (Read by Dr. Russell)

7. "Evidence that Meteorites are Fragments of One or More Celestial Bodies of Planetary Dimensions," Dr. Asbjörn P. Ousdal, University of Southern California, Los Angeles, California.

8. "Removing Lawrencite from Meteorites," Dr. H. H. Nininger, American Meteorite Museum, Winslow, Arizona.

9. "The Polar Coördinate Number of a Meteoritic Fall," Dr. Frederick C. Leonard.

10. "Concerning the Observability of Meteoritical Phenomena on the Moon and the Nearer Planets," Walter H. Haas, University of New Mexico, Albuquerque.

11. "Oxidation Studies at the Barringer (Canyon Diablo, Arizona) Meteorite Crater," Dr. H. H. Nininger.

*†12. "The Strangest Meteorite Ever Found," C. E. Graves, 1530 Atlas Avenue, Hammond, Indiana.

*†13. "Terminal Ballistics of Meteorites," Dr. John S. Rinehart and Dr. Marguerite M. Rogers, Naval Ordnance Test Station, China Lake, California.

*14. "A Preliminary Report on the Distribution of Gallium, Palladium, Gold, and Nickel in 45 Iron Meteorites," Dr. Harrison Brown and Dr. Edward Goldberg, University of Chicago and Argonne National Laboratory, Chicago, Illinois. (Read by Dr. Leonard)

15. "Another Unusual Meteor," Dr. H. H. Nininger.

Morning Session, September 7

*16. "The Nininger Collection of Meteorites," Addie D. Nininger, American Meteorite Museum, Winslow, Arizona. (Read by Dr. Nininger)

17. "Intensity Variations in the Spectra of Perseid Meteors," Dr. John A. Russell, University of Southern California, Los Angeles, California.

18. "Miscellaneous Notes on Meteorites from Holbrook, Richardton, Xiquipilco, and Mount Elden," John Davis Buddhue, 99 South Raymond Avenue, Pasadena 1, California. (Read, at the author's request, by Dr. Leonard)

19. "The Possible Preservation in Concretions of Traces of Ancient Meteorites," Dr. Lincoln La Paz.

20. "A Meteorite, Probably Canyon Diablo, from a Prehistoric Site near Flagstaff, Arizona," L. F. Brady, Museum of Northern Arizona, Flagstaff, Arizona.

21. "Meteorite Craters," L. F. Brady.

22. "The Weatherford, Oklahoma, Meteorite (ECN = +988,358)," Dr. Carl W. Beck and Dr. Lincoln La Paz, University of New Mexico, Albuquerque.

Afternoon Session, September 7

23. "Further Evidence concerning the Wolf Creek, Western Australia, Crater (ECN = —1278,192)," Dr. Frederick C. Leonard.

24. "Margin of Error in Fireball Surveys," Dr. H. H. Nininger.

25. "Crater Mound ('Meteor Crater'), Arizona: Is its Origin Geologic or Meteoritic?," Dorsey Hager, 801 Continental Bank Building, Salt Lake City, Utah.

*26. "A Note on Some Witnessed Sideritic and Siderolitic Falls, Discussed in Avicenna's 'Sanatio,'" Mohd. A. R. Khan, Hyderabad Academy, Begumpet, Hyderabad, Deccan, India. (Read by Dr. Leonard)

27. "The Nortonite Shower of Norton County, Kansas, and Furnas County, Nebraska," Dr. Lincoln La Paz and Dr. Carl W. Beck.

In the course of the Tuesday afternoon session, President King read a letter from Dr. Harrison Brown of the Institute for Nuclear Studies of the University of Chicago, in which Dr. Brown invited suggestions from members of the Society on the compilation of a comprehensive catalog of meteoritic falls and of a complete file of meteoritical literature. In particular, Dr. Brown requested that President King appoint, or cause to be appointed, a committee of 3 persons to act as a liaison group between the Society and the editorial committee of the project, which has been made possible thru a grant from the Rockefeller Foundation.

Following the afternoon session on September 6, a meeting of the Council was held. President King, Secretary Monnig, Treasurer Brady, Editor Leonard, and Councilors Buddhue, Cleminshaw, and (Ex-President) La Paz were present. The Council regretfully accepted the resignation of Secretary Oscar E. Monnig, necessitated by the pressure of his personal business, to be effective at the adjournment of the meeting, and appointed Dr. John A. Russell of the University of Southern California to serve as his successor during the remainder of the 1946-50 term.

The Society dinner was enjoyed by members of the Society and their guests at the Tick-Tock Restaurant in Hollywood, on Tuesday evening.

Following the dinner, the party adjourned to the Griffith Observatory and Planetarium in Griffith Park, Los Angeles, where an "open house" had been planned by Associate Director C. H. Cleminshaw. The guests evinced special interest in the Observatory's excellent collection of meteorites and in the photographs and models of terrestrial and lunar craters. At 8:30 o'clock, Dr. Cleminshaw gave a special lecture in the planetarium chamber, in the course of which the audience was whisked thru space to within a thousand miles of the surface of the Moon! This feat was accomplished thru the medium of special projectors designed and built at the Observatory. The capabilities of the planetarium instrument, including the reproduction of meteors, the aurora borealis, and greatly accelerated planetary motions, were admirably demonstrated to the delight and amazement of the audience, some members of which had never before had the opportunity of witnessing a planetarium demonstration.

At the close of the final session for papers, on Wednesday afternoon, the members present voted unanimously to express their appreciation to the University of Southern California for serving as the institutional host to the 12th Meeting, to Dr. Cleminshaw for the very enjoyable evening at the Griffith Ob-

servatory, and to Dr. and Mrs. Russell, Dr. King, and Dr. Leonard for their respective parts in arranging the details of the meeting.

Thru the courtesy of Director Ira S. Bowen of the combined Mount Wilson and Palomar Mountain Observatories, and the arrangements of President King, the third and last day of the 12th Meeting, September 8, was devoted to an all-day excursion to the great Observatory on Palomar Mountain in San Diego County. The party was conducted thru the principal parts of the Observatory by Mr. Byron Hill, the resident engineer. In addition to viewing the 200-inch Hale telescope from the gallery, the group visited the floor below the telescope, where the base of its supporting framework could be seen. Here too were the aluminizing chamber for the 200-inch mirror and the impressive central controls of the electrical system. The tour terminated in the dome of the 48-inch Schmidt telescope. As several members of the Society had never before been face to face with this type of instrument, Mr. Hill explained its peculiar properties and put it thru its paces. When one member of the group asked Mr. Hill whether the plateholders were cranked into place, Mr. Hill replied that it was not necessary to crank *anything* on the telescope—one simply pushed the correct button! This statement seemed to epitomize the mechanics of the entire institution.

Immediately following the formal adjournment of the 12th Meeting on Palomar Mountain, a special meeting of the Council was held outside the 48-inch dome. Present at this meeting were President King, Secretary Russell, Treasurer Brady, Editor Leonard, and Councilor (Ex-President) La Paz.

From the comments made as goodbys were said, the general consensus was that the 12th Meeting had fully maintained the high level of excellence set by its 11 predecessors.

Crater Mound ("Meteor Crater"), Arizona: Is its Origin Geologic or Meteoritic?* (Abstract)

DORSEY HAGER

Consulting Geologist, 801 Continental Bank Building, Salt Lake City, Utah

The writer has been interested in the origin of Crater Mound ("Meteor Crater"), Arizona, ever since his first visit there in 1921. In 1943 and in 1948, he made numerous visits to Crater Mound, and in 1948 prepared plane-table maps of Crater Mound and its environs. The results of the mapping and of the writer's studies of the geology furnish strong support for a geologic rather than a meteoritic origin of Crater Mound.

The writer finds the Crater and the Mound to be two separate, but interrelated, geologic features. The present Mound is the remnant or skeleton of an elliptical dome with a sink in its apex, which forms the Crater. Originally, the dome was far higher, perhaps 1000 feet or more above its present height, and the blocks of Kaibab limestone and the Coconino sandstone that are found out of normal position above the Moenkopie red-beds are evidence of weathering, not of explosive or impact action. The Crater is far younger than, and therefore subsequent to the formation of, the dome. The age of Crater Mound, if the writer's interpretations are correct, lies in the measure of *millions* rather than *thousands* of years.

The writer finds no direct evidence for a steam explosion or for explosive

*An invitational paper, delivered at the 12th Meeting of the Society, Los Angeles, California, 1949 September 6-8.

impact action, due to meteoritic action; in fact, if such action took place, the evidence has been eroded away.

The present form of the Mound is the result of many thousands of years of erosion. Furthermore, Crater Mound lies on the axis of the large northwest-trending Sunshine Nose, and its long axis and that of Sunshine Nose both strike N. 8° W.—a natural result of their being related.

A ring syncline, with a drainage outlet to the northeast, lies outside and around the rim, from ½ to ¾ths of a mile from the center of the Crater.

Two grabens (faulted blocks) occur—one on the north and the other on the south end of the Mound; both were probably at one time part of a larger single graben.

The similarity of Crater Mound to Upheaval Dome in Grand County, Utah, suggests a genetic relationship.

The only positive information to support a meteoritic origin lies in the relatively small amount of meteoritic fragments found in the vicinity of Crater Mound, the presence of which could be a purely adventitious occurrence. Evidence of a buried meteorite within the Crater is so far negative.

In conclusion, the writer offers several geologic hypotheses that might explain the origin of the Mound and the later formation of the Crater.

Abstracts of 5 Papers Read at the 12th Meeting of the Meteoritical Society

H. H. Nininger
American Meteorite Museum, P. O. B. 1171, Winslow, Arizona

1. *Removing Lawrencite From Meteorites.*—This paper describes a method of alcohol treatment for removing iron proto-chloride from meteoritic specimens.

2. *Another Unusual Meteor.*—This is a record of the observations made by the author on what seems to have been a spiraling meteorite, as indicated by the indirect course of the observed meteor. The color of the meteor also was unusual. This fact may, or may not, be significant.

3. *Oxidation Studies at the Barringer (Canyon Diablo, Arizona) Meteorite Crater.*—This is a discussion of two kinds of small objects found around the Barringer (Canyon Diablo, Arizona) Meteorite Crater that are believed to have had their origin in a metallic vapor cloud that was produced by the impact explosion.

4. *Margin of Error in Fireball Surveys.*—This is a presentation of the difficulties involved in making fireball surveys. A discussion is included of the methods by which the inaccurate reports of untrained observers may be made use of for obtaining an approximation to fireball trajectories and for locating meteoritic targets.

5. *The Nininger Collection of Meteorites* [*By Addie D. Nininger*].—This is an introduction to a new catalog of the Nininger collection of meteorites, including considerable descriptive material and identification data. The main objective of the catalog is to bring down to date the concrete results of a program of search for meteorites that is now in its 27th year.

The Collection and Identification of Air-borne Particles* (Abstract)

W. D. Crozier *and* Ben K. Seely
New Mexico School of Mines, Socorro

Means have been developed for the collection, and the condensation in a small space, of air-borne particles of sizes ranging down to well below one micron (1μ). The collecting apparatus may be taken aloft in an airplane, or it may be used on the ground. Methods have been developed for combined microscopic and chemical study of particles in the collections. Among the chemical procedures used are qualitative tests for iron, nickel, cobalt, and copper. Particles have been collected from the air, giving positive tests for iron and nickel; thus far, no cobalt has been detected.

Terminal Ballistics of Meteorites† (Abstract)

John S. Rinehart *and* Marguerite M. Rogers
Naval Ordnance Test Station, China Lake, California

We have a number of experimental results relating to the impact of high-velocity particles on various materials. These results are being presented in the hope that they may lead to a better understanding of phenomena associated with the impacts of meteorites. In order will be taken up:

(1) The physical attributes of meteorites important in studying impacts; (2) the characteristics of target material; (3) phenomena associated with impact; and (4) a discussion of existing craters.

Concerning the Observability of Meteoritical Phenomena on the Moon and the Near Planets* (Abstract)

Walter H. Haas
Department of Mathematics and Astronomy, University of New Mexico, Albuquerque

The visibility of such meteoritical phenomena as meteors, impact-flares, craters caused by meteoritic impacts, and long-enduring meteoric trains on the Moon and the nearer planets is briefly considered.

The 13th Meeting of the Society in 1950

At the 12th Meeting of the Society, in Los Angeles and on Palomar Mountain, California, on 1949 September 6-8, the Council accepted the invitation of the Museum of Northern Arizona, Flagstaff, Arizona, tendered by L. F. Brady, Curator of Geology in the Museum and Treasurer of the Society, to hold the 13th Meeting of the Society at that institution, on 1950 September 5-7. For the last-named date an excursion is scheduled to the nearby Canyon Diablo Meteorite Crater.

John A. Russell, *Secretary*

*Read at the 12th Meeting of the Society.
†Read by title at the 12th Meeting of the Society.

President of the Society: Arthur S. King, 925 Topeka Street, Pasadena 6, California

Secretary of the Society: John A. Russell, Department of Astronomy, University of Southern California, Los Angeles 7, California

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

A.A.V.S.O. Meeting at Harvard: The 38th Annual Meeting of the A.A.V.S.O. was held at the Harvard Observatory on Friday and Saturday, October 14 and 15, 1949; the largest annual meeting held since before World War II. Members were present from Maine to Washington, D. C., and from as far west as Wisconsin. As is usually the case, the weather conditions were ideal for a large turnout of members and their guests, an attendance which at times well exceeded a hundred persons.

The Council met on Friday afternoon and elected fifteen new members, as well as one patron, the latter being Dr. Henry S. Shaw of Melrose, Massachusetts. The active members elected are listed herewith.

Luverne E. Armfield, 635 Reublin Court, Elyria, Ohio
Dale E. Bufkin, 366 Hubbard, Elgin, Illinois
George C. Claridge, St. Norbert College, West de Pere, Wisconsin
George Diedrich, 653 Weller Road, Elyria, Ohio
William H. Galbraith, 7820 Montana Avenue, Lemon Grove, California
Walter H. Hackler, Box 74, Indianola, Illinois
Jeremy H. Knowles, 7 Pierce Street, Marblehead, Massachusetts
John E. Lankford, 3118 Central Avenue, N.E., Washington 18, D. C.
C. C. Moulton, 121 Meadow Road, Longmeadow, Massachusetts
William Penhallow, 346 Harris Avenue, Woonsocket, R. I.
Fred A. Pflug, 685 Centre Street, Jamaica Plain 30, Massachusetts
Taylor Z. Russell, 20052 Chalmers, Detroit 5, Michigan
Joyce Schwartzman, 17 Cochituate Road, Newton Highlands, Massachusetts
Walter A. Stevens, 8 Hawthorne Road, Larchmont, New York
Calvin A. Toche, 1122 Third Avenue, Crockett, California

Proposals for necessary changes in the Constitution and By-Laws were approved, the same to be presented for final action to the general assembly at the 1950 Spring Meeting. It was also voted to hold that meeting at the Pennsylvania State College, at a time to be agreed upon by that College and the Association.

Plans were also discussed relative to a closer connection between the Astronomical League and the Association, especially as regards the development of better cooperation between observing sections in the different A. L. member-groups. Plans were also considered for the part which the AAVSO would play in the Annual 1950 Meeting of the League to be held at Wellesley College early next July.

On Friday evening the Observatory lecture hall was filled to near capacity by members who listened to an interesting and informative talk by Dr. Helen S. Hogg of the David Dunlap Observatory. She recounted incidents in the lives of some little-known-about astronomers of the 18th century, including such persons as Wales, Bailly, and Le Gentil. Dr. Hogg has made a special study of such astronomers, and she presented many facts and incidents in their lives of which most of us were totally unaware.

On Saturday morning the regular business session was opened at 10 o'clock, with President David W. Rosebrugh in the Chair, and an attendance of more than eighty persons. After the reports of the Secretary and Treasurer were read and approved, the 18th Annual Report of the Retiring Recorder was presented. Some of the outstanding features of the report are the following.

Just over 50,000 observations by 141 observers were received, including more than 20,000 by 49 observers in 18 foreign countries—a total of 780 individual reports. Leading observers were Messrs. Cyrus F. Fernald of Wilton, Maine, with 7,654 estimates; Reginald P. de Kock of Capetown, South Africa, with 5,210; Paul Ahnert of Germany with 3,713; and Leslie C. Peltier of Delphos, Ohio, with 2,501 estimates. These four observers contributed 38 per cent of the total. The top eight observers contributed 50 percent of the total. Messrs. Hartmann, Oravec, Bogard, Greenley, Rosebrugh, Chassapis, Renner, Lacchini, and Escalante each reported between 1,000 and 2,000 observations. Our foreign observers sent in 20,277 observations, while those in the United States contributed 29,729.

The report of the Chart Curator indicated the distribution of 3,449 charts and 7 AAVSO Star Atlases to 140 observers. The original chart tracings, of inestimable value to the Association, are safely guarded in a fire-and-waterproof strongbox and a duplicate set is on deposit at the Harvard Observatory.

Mr. Heines' report, as director of the work of the Solar Division, showed continued activity and progress; a total membership of 185 distributed over 29 states and 12 foreign countries. The total number of sunspot observations for the year was 7,594, or a grand total to September 1 of 60,674. The American Relative Sunspot Numbers for the four-month period from May through August were 147.4, 154.5, 153.6, and 163.7, respectively. Other activities of this division include the granular solar surface, color observed in the spots, unusual spot configurations and colors, foreshortening of sunspots, migratory birds, delineation and spot measurements, solar radiation, and "seeing" conditions. The Auroral project is now a part of the work of this Division and is in the hands of Roy A. Seely, Assistant Director.

Messrs. Joseph Ashbrook, Cyrus F. Fernald, Richard M. Hamilton, and Donald H. Menzel were elected to the Council for the two-year term 1949-51. Later the Council elected the following officers:

President	Neal J. Heines
1st Vice President	Martha E. Stahr
2nd Vice President	Donald H. Menzel
Secretary	Clinton B. Ford
Treasurer	Percy W. Witherell
Recorder	Margaret W. Mayall
Honorary Recorder	Leon Campbell

The following papers were presented. "Solar Prominences," Donald H. Menzel; "Boxes," David W. Rosebrugh; "Surface Details of Jupiter III," Walter H. Haas; "A Photoelectric Photometer," Stanley W. Brower; "Variable Star Observers in Germany," Richard M. Hamilton; "Nova Velorum," Dorrit Hoffleit; "The Photographic Light Curve of Nova Scuti," Franklin Kameny; "Regulating Watches by Vibration," Ralph A. Wright; "Observatories in Europe," Marjorie Williams.

Following the afternoon session, which had been devoted mainly to the pre-

sentation of the papers, adjournment was made to attend the Tea in the Observatory Residence as guests of Dr. and Mrs. Shapley.

The Saturday evening banquet was largely in the form of a testimonial to the Retiring Recorder. Following a well served meal, amid much din of conversation at each table, Treasurer Witherell, acting as M.C., introduced several speakers—principally from the ranks of the older generation of member-observers. Included were Miss Helen M. Swartz, Morgan Cilley, David W. Rosebrugh, Charles W. Elmer, and Roy A. Seely. The latter's remarks referred mainly to the presentation to the Retiring Recorder of a collection of more than 100 congratulatory letters sent in by members from all parts of the world. The Retiring Recorder acknowledged as best he could this greatly appreciated gift and token of friendship from his many friends over the past 35 years during which he has been closely associated with the many activities of the AAVSO.

Dr. Shapley concluded the evening's program with his recounting of the Ten Highlights of the Year, which were:

1. The operations of the past year in large optical glass—Lick Observatory's acquirement of the 120-inch disc from California Institute of Technology; the Astronomer Royal's acquisition of the 98-inch disc from the McGregor Foundation for the Isaac Newton Memorial Telescope; the ordering of the 74-inch mirror discs for the Mount Stromlo Observatory in Australia and the Helwan Observatory in Egypt; the ordering of an equally large telescope blank for San Michele Observatory in France; and a few somewhat smaller items for Upsala and Stockholm in Sweden.

2. The setting into operation of three famous telescopes that have long been underway—the 200-inch Hale reflector, the 48-inch Schmidt telescope on Palomar Mountain; and the Radcliffe 74-inch reflector at Pretoria, South Africa.

3. The demonstration by Winfield W. Salisbury at Cedar Rapids, Iowa, of the absence of a lunar eclipse effect when observations are made by radar in wave-lengths of 1.25 cm (April and October eclipses of this year). Apparently the moon is covered with a non-conducting layer of dust.

4. The discovery with the 48-inch Schmidt telescope of an asteroid of short period (400 days) with an elongated orbit which, for the first time, shows asteroidal bodies that periodically go nearer to the sun than the planet Mercury.

5. The new Whipple cometary theory which suggests that the comet heads are a composition of various ices and meteoric particles, the ices including ammonia, methane, water, cyanogen, carbon dioxide and carbon monoxide. These melt and form a head and sometimes a resisting medium when near the sun.

6. The new flood of interesting theories as to the origin of cosmic rays, especially those by Fermi, Salisbury, Menzel, and Teller, which involve magnetic fields, and indicate perhaps that the cosmic rays are of solar system origin.

7. The discovery of the second satellite of Neptune by G. P. Kuiper.

8. W. J. Luyten's discovery of a nearby pair of extreme dwarf red stars, one of which undergoes frequent and mysterious flares and flashes.

9. Dr. Eggen's marvelously precise work on the colors of stars.

10. The discovery by Dr. Haro of bright line radiation in the spectra of objects heretofore identified as globular clusters, but apparently are Pleiades-like groups composed of stars and nebulosity in the Andromeda Nebula—an important contribution from Mexico's Tonanzintla Observatory under Señor Erro's direction—the observatory that now possesses the largest objective prism, 26 inches in diameter.

Thus terminated the 35th consecutive meeting of the Association held in

Cambridge since the first annual meeting in 1915. A new Recorder, Mrs. Margaret W. Mayall, long active in the variable star field, takes over the task of supervising the reports of the observers and compiling the results. The Retiring Recorder is to have an office at the Observatory, where he can complete for publication some of the investigations on which he has been working in recent years.

Observations received during September: A total of 4,715 observations was received during September, 1949, from the following 67 observers:

Observers	No. Var.	No. Ests.	Observers	No. Var.	No. Ests.
Adams	29	65	Kelly	8	10
Ahnert	24	141	Kirchhoff	39	68
Albrecht	11	11	Knowles	4	25
Ancarani	21	33	de Kock	126	528
Ashbrook	2	16	Kratz	9	9
Bajocchi	15	30	Lacchini	53	70
Ball	1	1	Lankford	28	96
Blunck	16	16	Le Iletter	19	21
Bogard	57	87	Lee	33	53
Boone	5	5	Lowder	12	18
Buckstaff	19	46	LeVaux	37	43
Bufkin	9	10	Luft	5	26
Cain	15	16	Miller	80	138
Chandra	22	25	Oravec	58	110
Charles	21	42	Parks	40	75
Cilley	27	50	Pearcy	116	118
Daley	7	26	Peltier	78	274
Darling	29	49	Penhallow	49	102
Darnell	1	5	Pierson	28	28
Davis	27	87	Reeves	1	2
Debono	5	16	Renner	137	137
Dillon	6	11	Rosebrugh	18	179
Edmonds	11	25	Schoenke	1	1
Escalante	4	4	Segers	18	110
Estremadoyro, G. A.	3	3	Stevens	17	37
Fernald	281	749	Tifft	28	88
Ford	23	24	Upjohn	42	42
Greenley	67	101	Waters	3	3
Halbach	39	39	Webb	19	28
Hamilton	4	16	Weber	40	40
Hartmann	134	141	Welker	19	31
Herring	43	75	Yamada	35	130
Hiett	12	26	Yoshihara	37	210
Holloway	35	74			

October 20, 1949.

Comet Notes

By DANIEL L. HARRIS III

Comet Johnson (1949 *d*), which was announced in last month's Comet Notes, continues to be in a good position for observations in the southern hemisphere, but as its predicted magnitude is about 14.5 it will be too faint to observe with small telescopes. Dr. Cunningham notes that the comet may have made a moderately close approach to Jupiter in 1932.

Comet Ashbrook-Jackson (1948 *i*) will again become visible in the morning sky, but will be very faint (about the 16th magnitude).

On September 18 a new comet (1949 *e*) was discovered by Mrs. Pelageja

Shajn of the Simeis Observatory, it being a faint object of the 12th magnitude, diffuse with central condensation and a tail less than one-degree long. It was also discovered independently by Schaldach on September 20 at the Lowell Observatory. Miss Amelia White was able to obtain a preliminary orbit, but the period is still very uncertain, being about $7^{y}.8 \pm 1^{y}.0$. The inclination is only 6°.6 to the ecliptic and the eccentricity is about 0.4. A schematic drawing of the orbit of this periodic comet is given (Figure 1) to illustrate its position with reference

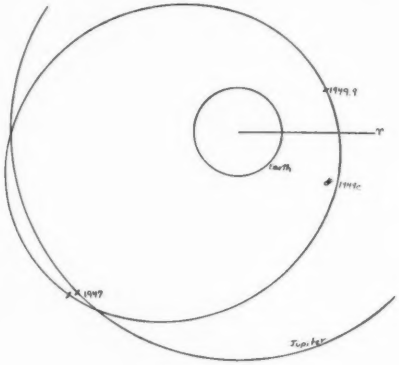

FIGURE 1

to the orbits of the Earth and Jupiter. It will be noted that the two orbits are so situated that the comet approached Jupiter to about one-half astronomical unit in 1947. According to Cunningham the two bodies had been quite close for several months previously and it is likely that the orbit was altered considerably.

As the comet will remain at about magnitude 12.5 we give no ephemeris since it will be beyond the reach of small telescopes.

Warner and Swasey Observatory, East Cleveland, Ohio.

General Notes

Professor G. B. Blair of the University of Nevada, an enthusiastic promoter of the interests of amateurs in astronomy, died suddenly from a heart attack on September 19. He attended and had an active part in arranging the meeting of the Western Amateur Astronomical Congress in Los Angeles in August.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on October 14, 1949, in the Randall Morgan Physics Laboratory of the University of Pennsylvania. The speaker, Dr. John H. Pitman, Sproul Observatory, Swarthmore, Penna., took as his topic, "Exploring the Universe."

Dr. Charlotte Moore-Sitterly of the National Bureau of Standards has been elected an Associate of the Royal Astronomical Society of Great Britain. Associate memberships are awarded by the Society to distinguished foreign astronomers and astrophysicists. Dr. Sitterly is the first woman to receive this distinction, although the late Annie J. Cannon of the Harvard College Observatory

was an honorary member of the Society. The Royal Astronomical Society was founded in 1820; it is one of the world's oldest and most distinguished astronomical societies. Dr. Sitterly was elected in recognition of her outstanding contributions in the fields of astronomy and astrophysics, particularly her extensive compilations of multiplet tables and her work in identifying lines in solar and sunspot spectra.

The Atlanta Astronomers' Report, Volume II, No. 6, has recently come. It is a 17-page mimeographed pamphlet, and is concerned chiefly with astronomical interest in and around Atlanta, Georgia. This issue contains an article on "The Stellar Interferometer," one on "Astrology," and several shorter items. It states that construction of an observatory at Agnes Scott College, to house a 30-inch reflecting telescope, has been begun, and that the observatory may be in operation within a year.

Astronomy Club of Wheeling, West Virginia

An organization of amateur astronomers has recently been formed in Wheeling, West Virginia. This has been prompted and astronomical interest has been stimulated by a gift of an observatory and two telescopes to be put to use in Oglebay Park. A condition of the gift is that the telescopes will revert to the donor if they are not used by the club.

Meeting of "Ohio Astronomers"

On October 22 a meeting of the "Ohio Astronomers" was held in Cleveland, Ohio. This is essentially, though not officially, a regional meeting of the American Astronomical Society since astronomers from Michigan, Indiana, Columbus, Pittsburgh, Cincinnati, etc., were in attendance. A progress report of present research at the Warner and Swasey Observatory was the principal feature of the meeting.

Science Talent Search

The ninth annual Science Talent Search is now being conducted by the Science Clubs of America. The search culminates in a competition for the Westinghouse Grand Science Scholarship of $2800, and other Westinghouse awards. The following address may be used in case further information is desired: Science Clubs of America, 1719 N. Street, N. W., Washington 6, D. C.

Provisional Relative Sunspot Numbers for September, 1949*

1	165	11	176	21	130
2	165	12	173	22	148
3	184	13	170	23	144
4	184	14	168	24	127
5	174	15	172	25	136
6	188	16	159	26	108
7	184	17	182	27	94
8	170	18	210	28	84
9	160	19	154	29	55
10	164	20	170	30	51

Mean Value for September
R = 151.6

*From the Zürich Observatory, furnished by Mr. Neal J. Heines.

The Nantucket Maria Mitchell Association, founded in 1902, has recently issued its forty-seventh annual report for the year ended January 31, 1949. It contains the names of persons connected with the Association in various capacities, such as officers, members of advisory council, staff and committees; also a chronological record of important events in the life of Maria Mitchell and of the Association, beginning with the birth of Maria Mitchell in 1818 and ending with a reference to the book by Miss Helen Wright entitled "Sweeper in the Sky," published in 1949; also the minutes of the annual meeting; various reports; and, finally, a membership list. The Association is to be commended for its continued activity through a long period of years.

Publications of the Astronomical Society of Japan

Volume I, Nos. 1, 2, of a publication bearing the above name has recently been received. It is stated on the cover that the Astronomical Society of Japan was founded in 1908. It seems strange that this should be the first publication after so long a history of the Society. This pamphlet consists of fifty pages and is in the English language. It is possible, and quite probable, that an earlier publication of this Society exists in Japanese. The papers in this issue are advanced in character, pertain to recent developments, and are written by Japanese scientists. It is gratifying to note such revival of scientific work so soon after the disaster of war which this country suffered.

The Cleveland Astronomical Society

The activities of the Society for the program year 1949-1950 opened on October 7 with a lecture on "Radio Astronomy," with Dr. Ralph E. Williamson of the David Dunlap Observatory of the University of Toronto as the speaker. The development of this interesting new branch of astronomy was traced from its beginning in 1931, when Jansky of the Bell Telephone Laboratories first detected this type of radiation while searching for terrestrial sources of radio interference, to the post-war adaptation of radar equipment and the detection of radiation of various wave-lengths from the sun, the Crab Nebula, and several points along the plane of the galaxy. Of particular interest to the audience was the fact that one of the radiation regions, known as a "radio star," is located in the constellation of Cygnus, where extensive work has been carried on recently by various members of the research staff of the Warner and Swasey Observatory. As this radiation is irregular and changes rapidly, it is conjectured that it is coming from a relatively small object rather than from an extended area.

The speaker emphasized that although radar equipment is used, the radiation is merely received and hence the program is not similar to the radar experiments carried out by the U. S. Army Signal Corps and others. He also pointed out that while the work has the excitement associated with a new field, it has the disadvantage that cloudy skies cannot be used as an excuse for "closing up for the night," as the radiation being investigated is capable of penetrating through this barrier. Diagrams were shown illustrating the variation in the sun's appearance when different wave-lengths were monitored.

The meeting was held, as usual, in the Warner Auditorium of the Warner and Swasey Observatory of Case Institute of Technology in East Cleveland. Some eighty persons enjoyed the presentation of this fresh topic by the stimulating speaker.

PAUL ANNEAR, *Recording Secretary*
Burrell Observatory, Baldwin-Wallace College, Berea, Ohio, October 24, 1949.

Reduction of Observations of Occultations

H. M. Nautical Almanac Office wishes to inform those observers of lunar occultations, who prefer to reduce their own observations, that for 1950 a correction of —1".5 is to be applied to the Moon's mean longitude. This is equivalent to applying a correction of —0^h.00076 to the observed time before entering the ephemeris of the Moon. Provision is made for this correction on the occultation reduction cards.

It should be emphasized that this is not a request for observers to do their own reductions, as the Office is satisfied to receive either times of observation only or partial reductions, in which the station and star positions are reduced and which are unaffected by the correction. But as some observers are known to prefer to complete the reduction, it will be more convenient if they apply the same correction.

The arrears in the reduction and discussion of observations are now being overtaken quite quickly. In order to allow the work to be kept up to date, observers are requested to send their observations for any quarter so that they will reach H.M. Nautical Almanac Office within six months of the end of the quarter to which they refer. Observers who desire to reduce their own observations would help the work considerably if, when their reductions cannot be finished within the suggested period, they would supply within that period a list of times of observation only, with a note that they intend to do the reductions.

H.M. Nautical Almanac Office, Royal Greenwich Observatory,
Herstmonceux Castle, Nr. Hailsham, Sussex.

The George Eastman House

The George Eastman House, Inc., a public educational institute to further the knowledge of photography's means, accomplishments, and potentialities in every field, is a living memorial to George Eastman. It is under the control of a corporate body of eleven directors. The Eastman House has been contributed to the corporation by the University of Rochester. The Eastman Kodak Company has loaned to it the Eastman Historical Photographic Collection. Many others have contributed to this independent institute which is designed to further the knowledge and appreciation of photography in every field.

It is fitting that the home Mr. George Eastman built in Rochester, New York, should thus become an educational focus in the field which was so greatly advanced by his genius, by placing on exhibit the technological developments and the applications of photography both in the historical past and the present progress in the entire field of photography.

The institute, with facilities for exhibitions, demonstrations, lectures and the showing of moving pictures, will be a national and international center for conferences on photography; for research in its history, science and application; for the education of school children by guided tours; for meetings of camera clubs and photographic organizations; for changing exhibitions of photographic work; for demonstrations of the latest apparatus and processes; for the screening of both historical and modern motion pictures; and for other related purposes.

The George Eastman House will be opened to the public on November 9, as announced by Dr. C. E. Kenneth Mees, president of the photographic center in Rochester. Plans for the opening include ceremonies to be held in the Eastman Theater and at the house on November 9. Distinguished visitors from the world of photography and related arts and sciences are expected to attend.

Construction of the Dryden Theater will begin shortly after the opening of the photographic center in November. The theater, a gift of Mr. and Mrs. George B. Dryden of Evanston, Illinois, will cost about $200,000. Mrs. Dryden is a niece of the late George Eastman.

The house itself is a magnificent Georgian Colonial home at 900 East Avenue, Rochester, N. Y. Eastman, the famed photographic pioneer, built it for himself and his mother in 1905. He bequeathed it to the University of Rochester at the time of his death in 1932, as a home for the university's president. Officially known as George Eastman House, Inc., it is expected to become a world center for the demonstration of photography as an art and science.

Announcement Office of Naval Research

The Office of Naval Research again intends to make available limited funds for the support of pure research in astronomy and astrophysics.

The National Research Council, at the request of ONR, has appointed an Advisory Committee of eminent astronomers to recommend specific projects for support by ONR. The Committee has suggested that the average cost per project should be about $3,000, with a maximum not appreciably in excess of $5,000. It is understood that in the case where a proposal is selected for support by ONR, negotiations will be entered into for a contract between the U. S. Navy and the institution at which the research will be conducted.

The Advisory Committee has recommended that for these relatively small contracts the maximum overhead charges should not be in excess of 10 percent, but all legitimate expenses in connection with the project will be chargeable to the contract.

Applications for the support of projects to be considered this winter should be received at the Office of Naval research *on or before December* 15, 1949. These should be addressed to:

Chief of Naval Research
Washington 25, D. C.
Attention: Code 432

Because of the pressure of time, each applicant is requested to submit *ten* copies of all application material (legible carbon copies on thin paper acceptable). Each application should contain a full description of the project, accompanied by a cost breakdown and, if possible, a letter of approval from the institution(s) at which the work will be performed. Letters of recommendation will be helpful to the members of the Advisory Committee in making their appraisal and should be sent by the writer directly to the above address, also by December 15.

Under the suggested arrangements it will not be possible to pay for the cost of publication of the results of the research. It is, however, understood that research results may be published freely through the usual channels.

The 200-inch Telescope Ready for Use

Because of the general popular interest in the "largest telescope in the world," we are printing here *in toto* a statement issued from the Office of Public Relations of the California Institute of Technology on October 22. This official, authentic, up-to-date news release will be eagerly read by all who have the slightest connection with astronomy and by others as well. EDITOR.

Additional polishing of the 200-inch mirror for the Hale Telescope on

Palomar Mountain has been completed, it was announced today by Dr. Ira S. Bowen, Director of the Mt. Wilson and Palomar Observatories.

The big mirror, which was removed from the telescope for final polishing last May, still has to be coated with alumnium before it goes back into the telescope tube. "We don't know for certain how long it will take to do this," Dr. Bowen said. "Considerable experimental work on the aluminizing tank remains to be done. While the original coating was good enough for our first test work, we are after a better one now. We may get it in three weeks, or it may take three months. We hope the telescope will be back in operation well before the first of next year."

The mirror was removed for more polishing when over a year of testing revealed the outer 18 inches of its surface was slightly turned up. There were spots where the surface was about 20-millionths of an inch too high, and it was to correct this that the additional polishing was ordered.

"We knew when the mirror was taken from the California Institute of Technology to the observatory that its surface was slightly high in this area," Dr. Bowen said. "It had been deliberately left high because we had anticipated some sag when it was placed in the telescope. When this sag did not develop to the extent we had anticipated, and tests under actual operating conditions revealed that we were not getting the accuracy we desired from this portion of the mirror, we decided to do some additional work on it. We expected this job to require some six months but it was actually completed in less than five.

"Although we believe we have now obtained as nearly a perfect surface as possible, we cannot be absolutely certain until the telescope has been tested further under actual operating conditions. If, after a year or so we believe we can further improve the mirror by additional polishing, we will undoubtedly remove it again and do such additional work as we deem advisable.

"The efficiency of the mirror has been improved considerably by the additional polishing. Under average seeing conditions it was good enough before we did this extra work. Now it is good enough to take full advantage of those exceptionally good seeing nights that occasionally occur. It is on these nights that the 200-inch will get in its best work and we are now in a position to take full advantage of them," he said.

Of the total time required to complete the additional polishing, only a small fraction—about seven hours in all—was spent in actual work on the surface of the mirror. It was exhaustive testing runs; removal and replacing of the mirror in the telescope after each short polishing run; determining from study of test photographs where, and how much, additional glass had to be removed, that consumed the greater portion of the five months of work. Weather, too, played an important part. Only the light from distant stars was used in testing, and Dr. Bowen and his staff time and again "waited out" the weather for the best possible seeing conditions and long periods of uniform temperature.

The polishing job was done by Don O. Hendrix, Mt. Wilson Observatory optician. Dr. John A. Anderson, who supervised figuring and polishing of the mirror from 1936 until its completion in 1947, retired before it was decided to attempt to improve it further. Gone too was Marcus Brown, who guided the actual polishing under Anderson's supervision, since the big Caltech optical shop where the original work was done had been closed. When it was certain that the additional work could be done at the Palomar Observatory, Hendrix, who did the mirrors for the 48-inch Schmidt camera, was assigned to the 200-inch.

Using polishing tools as small as 1x1¼ inches and as large as 12 inches in

diameter, Hendrix began cautiously removing more glass from the mirror last June. Some of the work he did by hand, other by machine. The smallest tools, which were made of cork, were used by hand to remove as little as 5 or 6 millionths of an inch of glass in small localized areas. For larger areas where as much as 20 millionths of an inch of glass had to be taken off, work was done by machine. The latter was specially built to do the job at the observatory.

Extreme care had to be taken to avoid removing too much glass. When polishing was in progress no one except those working on the mirror had access to the observatory floor. Before each polishing run the mirror had to be thoroughly cleaned to avoid the possibility of foreign matter getting on it and scratching its surface.

Final tests were completed late in September and the mirror pronounced ready for coating. The latter will be done at the observatory in a large vacuum tank especially designed and built for this purpose.

The first work to be done with the Hale telescope will deal entirely with taking direct photographs of nebulae and similar objects, both nearby and at the extreme range of the instrument which is of the order of a billion light years from the earth. This is twice as far as the largest instrument, the 100-inch telescope at Mt. Wilson, can reach.

The Palomar astronomers, who first obtained pictures of other stellar systems like our own at that distance last January, believe that the repolishing of the mirror will make it possible to photograph stars 20 percent fainter than those recorded on the first test plates. There is good reason to believe that the Hale telescope will now be able to record objects more than four million times fainter than the faintest stars you can see with the naked eye.

Photographs made last January revealed many more nebulae than stars at the limit of the telescope—giving evidence that the Hale breaks entirely away from our own stellar system and to the very depths of space. The faintest of these showed on the photographic plate as dim spots only a little larger than star images. Most of them, the Palomar astronomers believe, are average stellar systems at a distance of about one thousand million light years, although a few may be dwarf systems nearer than that and some giant ones even farther away. Not until a great many more plates are taken will it be possible to draw any more definite conclusions as to the size of these systems and their distance. It is with such nebulae, both far and near, that early work with the Hale will be concerned, Dr. Bowen said.

The Origin of the Solar System

The question as to how the earth and other planets came into their present form is a perennial one and frequent attempts have been made to answer it. On September 4, 1949, the University of Chicago Round Table devoted a period to the consideration of this question. Dr. Harrison Brown, Dr. Dirk ter Haar, Dr. Gerard Kuiper, and Dr. Rupert Wildt took part in that Round Table discussion. On October 10, Dr. Kuiper, in an address at the University of Chicago, elaborated his ideas on the subject. This lecture was reported in a University of Chicago news release as follows:

A new theory of the origin of the earth and planets from a sphere of gas and dust rotating around the sun during an interval of a thousand years three billion years ago was recently advanced by Gerard P. Kuiper, University of Chicago astronomer. Basing the theory on mathematical-physical calculations, Kuiper, internationally-recognized authority on the solar system, presented his

new hypothesis at a Midway university lecture sponsored by the College physical sciences staff. Five hundred scientists, students, and visiting professors crowded Kent Hall for the first announcement of the Kuiper theory on the origin of the solar system.

Linking together, for the first time with precision, the hydro-dynamical knowledge of vortex motion with astronomical data, the Kuiper theory shows that gas and dust, forming a nebula about the sun, would have contracted to a thin pancake, like the rings of Saturn, in the plane of the present orbits of planets. The thickness of the ring was one percent of its diameter.

Mass of the nebula, Kuiper estimates, would have been half as great as that of the sun. When the density of the pancake reached a critical value, it would have broken into a number of whirling eddies—*proto-planets* as Kuiper calls them—which would have continued to shrink and finally to have condensed into planets and their satellites. This critical density was not the same everywhere; it was a million times higher near Mercury than it was near Neptune. It was one-thousandth of earth's atmosphere in the vicinity of the earth and only one-ten-millionth of earth's atmosphere near Neptune.

Kuiper's theory is one of a half-dozen presented since 1755 when the German scientist, Immanuel Kant, speculated that the planets and the sun were formed from a single large rotating gaseous cloud, and the second to be advanced from the University of Chicago. The geologist, T. C. Chamberlin, and F. R. Moulton, astronomer, both famed among President Harper's men, introduced a concept on the origin of the earth in 1895. Their theory, a challenge to the Laplace hypothesis, advanced the idea that the earth was built by accretion of cold, solid material and that another star was involved in forming the solar system. This concept is essentially retained in the new theory, but it is not assumed now that the gas cloud was pulled out of the sun by a passing star. Kuiper's new theory is in all respects a modern version of the Kant theory. It differs, however, from the current (1944) theory of Carl Frederich von Weizsäcker.

Von Weizsäcker, German astrophysicist, advanced the theory that the sun was surrounded by a big cloud of gas with the density of about one-millionth of earth's atmosphere. He speculated that in this gas big vortices of laminar flow existed. These, he estimated, bounced against each other and in the region of contact small roller bearing whirls were formed from which the planets were later formed.

According to Kuiper's theory, based on modern hydro-dynamical data, the regular pattern of primary vortices conceived by Weizsäcker could not be present, and roller bearing regions could not form planets. Weizsäcker assumed that vortices alone were sufficient to cause planets. Kuiper shows instead that gravitational instability in the disc caused the vortices to break into proto-planets. "The roller bearings are too hot and not much denser than the surrounding nebula," Kuiper told his Midway university audience. "The roller bearings are very short-lived affairs and cannot give birth to planets." The University of Chicago astronomer's theory explains the masses of the planets, leads to their approximate composition, and accounts for planetary rotation and satellite formation.

Kuiper is able to explain the masses of the proto-planets from the size, shape, and density of the original pancake-nebula rotating around the sun. Since the present planetary masses are known by observation, Kuiper determined how much of each proto-planet went into the making of its planet. The earth used

1/120 of its proto-planet; Jupiter and Saturn used about 1/3 and Uranus and Neptune, about 1/20. Growth of the planets took place in a few thousand years, and the growth of the satellites in about a century.

The only feature still visible in the solar system resembling in shape the nebula from which the planets grew is the ring of Saturn. This ring failed to combine into one or two satellites because it was too close to Saturn.

As far as the composition of the planets is concerned, Kuiper uses the computations of D. ter Haar of the department of physics at Purdue University. The composition was largely determined by the temperature in the region in which they were formed. Planets close to the sun, such as Mercury, Venus, and Earth, are formed by dense materials (silicates—metals) which could condense at fairly high temperatures. The planets far from the sun, Jupiter, Saturn, Uranus, and Neptune, are formed of light materials—gases, water or ice, and hydro-carbons—and only a small percentage of heavy materials.

Kuiper explains the rotation of the planets, all observed to be in the same direction as their motion around the sun, by solar tides working on the proto-planets. Later the proto-planets contracted so rapidly they broke away from the solar tides and the rotations speeded up to the present values.

Ordinary or regular satellites were formed, according to the Kuiper theory, during the same period of contraction of the proto-planets. During that stage, the planets all looked like Saturn, except that the rings around them were much wider. Earth's moon is an exception. It is not, according to Kuiper, a normal satellite, but was probably formed as a double planet with the earth as a partner.

The condensation products which formed the earth were collected largely in solid form, "hailing" down in the manner first conceived by Chamberlin and Moulton. The moon preserved in her pock-marked face the fossil craters due to the impacts. On earth, they have disappeared by erosion, except in a few cases, such as the meteor crater in Arizona.

Kuiper, discoverer of two new moons in an equal number of years, announced the discovery of a second satellite to Neptune May 1, 1949, and of Miranda, fifth moon to the planet Uranus, in March, 1948. In February, 1948, he showed the presence of both carbon dioxide and small quantities of water and green areas on Mars, consistent with the presence of mosses and lichen.

Kuiper, who first achieved international distinction as a scientist for the discovery of several white dwarf stars, is also an authority on the hydrogen content of the stars, a field which he developed in connection with theoretical investigations of Dr. Subrahmanyan Chandrasekhar, distinguished service professor of theoretical astrophysics at the University of Chicago.

Book Reviews

Handbook of Chemistry (Seventh Edition), by Norbert A. Lange. (Handbook Publishers Inc., Sandusky, Ohio.)

Reviews of the preceding issues of this work have appeared in 1939, 1941, 1944, and 1946. In each of these the almost unlimited number of items included has been mentioned. In preceding editions there was a steady increase in the number of pages needed. The seventh edition shows a slight reduction, due not to omitting anything essential in the field but to omitting some of the mathematical tables which have constituted an appendix in earlier editions.

The table of contents shows the material to be grouped under 182 different

headings, mostly in tabular form. Twenty-five pages of index, in small type, furnish a ready means of locating any detail that may be sought.

The same comments are pertinent to this edition as were made concerning earlier ones, namely, that the printing is clear and lucid, the binding strong and durable, and the cover quite ornamental, in this case a beautiful shade of blue. It is, indeed, worthy of commendation to workers in the field of the natural sciences. It also contains many hints and suggestions of value to everyone, thus making its usefulness extend beyond the laboratory into every day activities.

—C.H.G.

The General Catalogue of Variable Stars, by Kukarkin and Parenago, Moscow, 1948.

Because of unfamiliarity with the Russian language on the part of most persons, the contents of the volume, whose title is given above, are to a large degree inaccessible. Action by the General Assembly of the International Astronomical Union at its meeting in Zürich in 1948 alleviated this situation to a certain extent. It was there decided that an English version of the Introduction and of the Remarks be issued. This has now been done under the supervision of Professor P. Th. Oosterhoff of the University of Leiden. It consists of a pamphlet of 31 pages. Because of the wealth of material it contains pertaining to the large number of variable stars listed, it will be of great value to workers in this field of astronomy.

The College Blue Book. (Post Office Box 311, Yonkers, N. Y.) The Sixth Edition of The College Blue Book, the standard work of reference of Higher Education in the United States and the World, is off the press with over 500,000 facts dealing with Higher Education.

It has been a regular office tool in thousands of High Schools, Libraries, Colleges and Universities as well as City and State Superintendents' offices and firms dealing with institutions of higher learning for over a quarter of a century.

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